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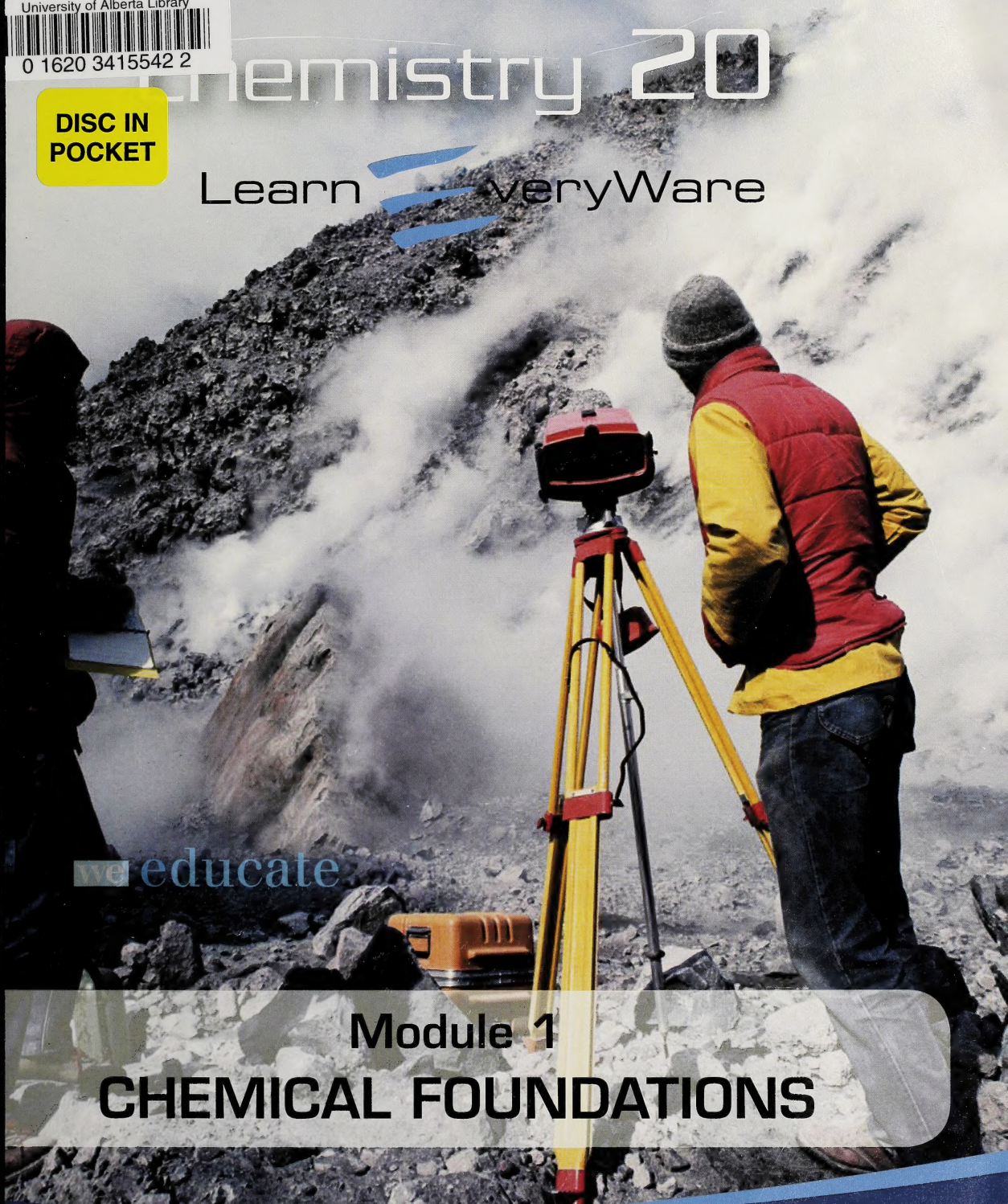

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Module 1
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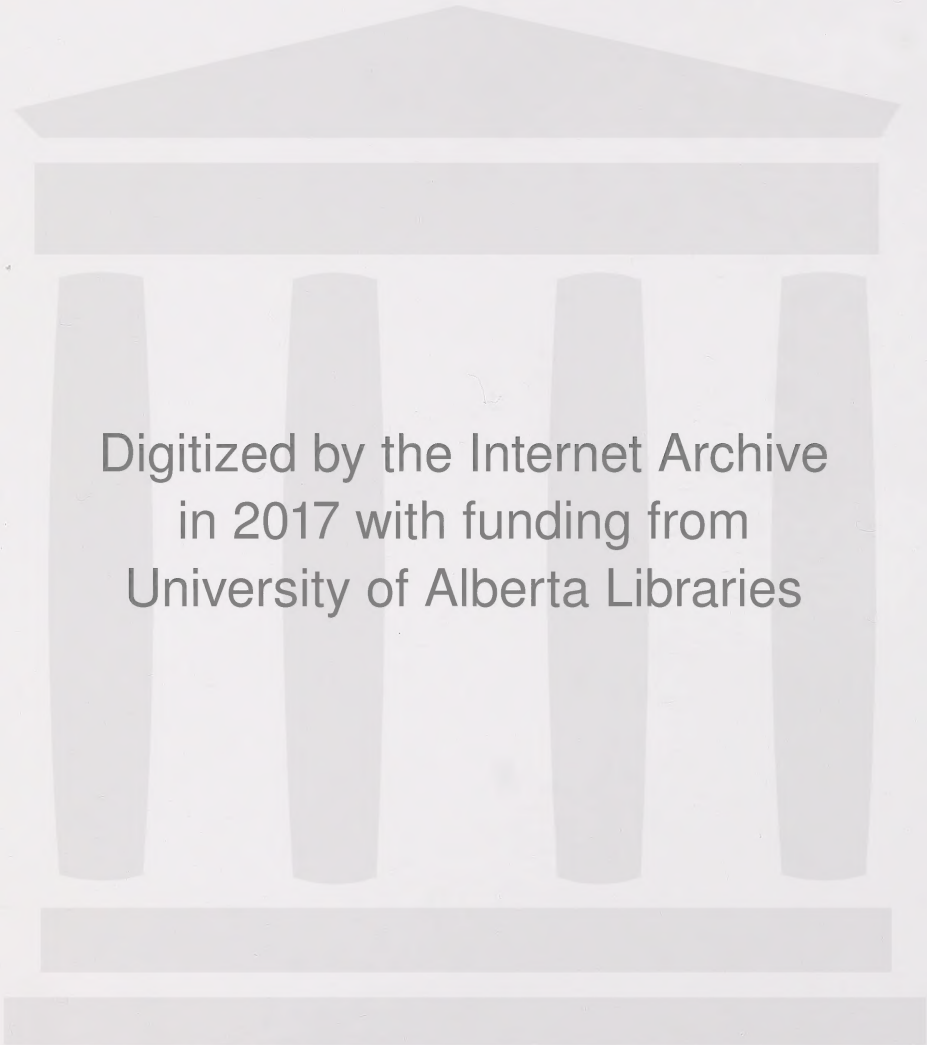
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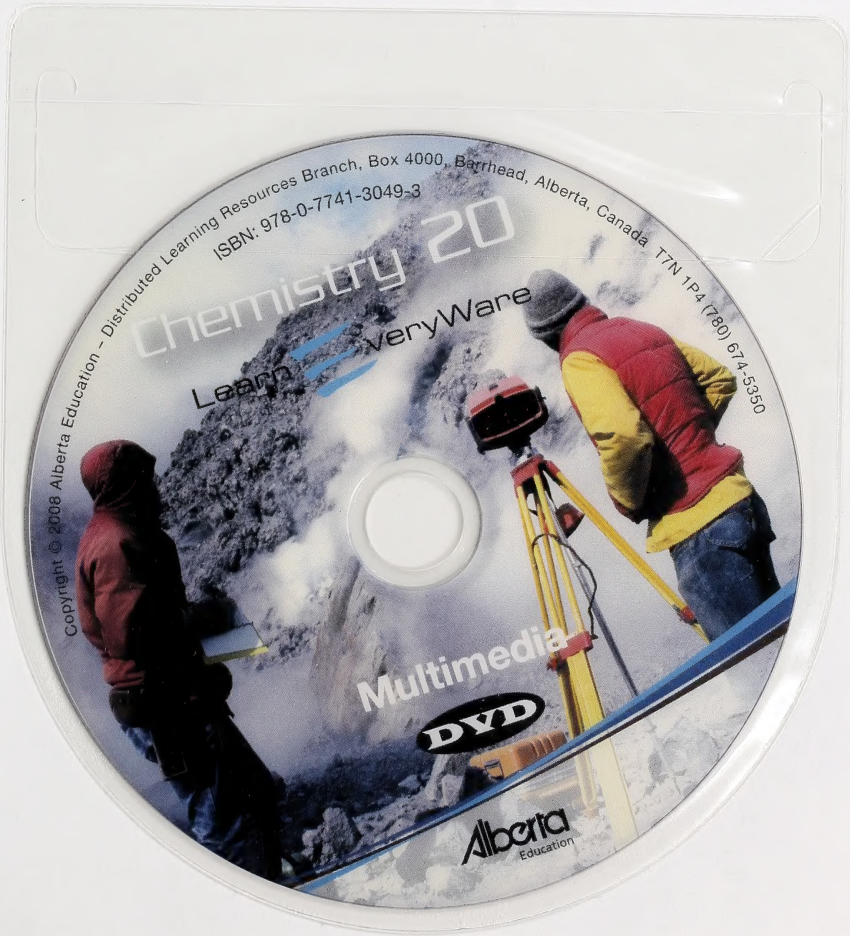
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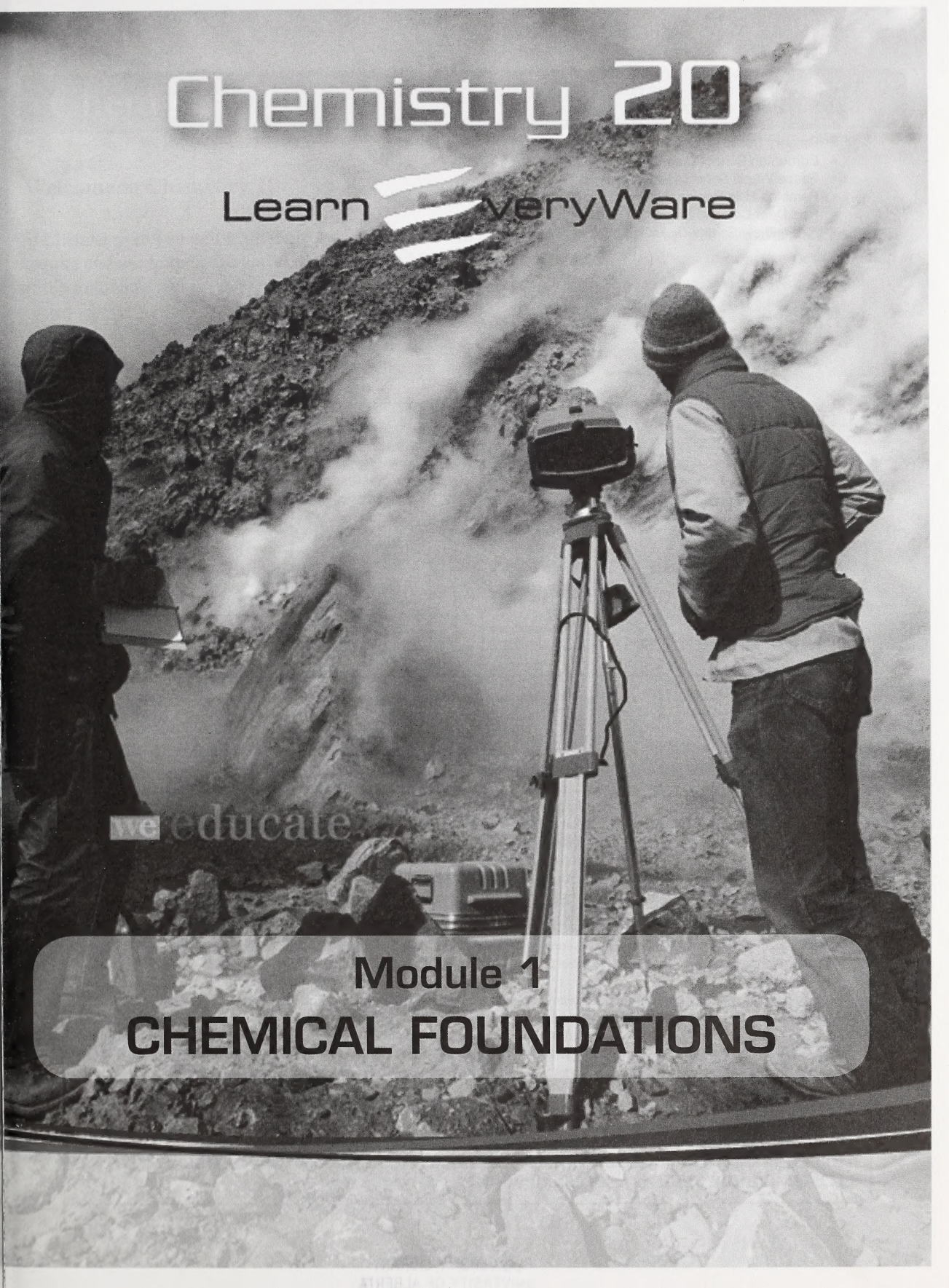

Module 1

CHEMICAL FOUNDATIONS

Chemistry 20 was created by Alberta Education in partnership with the following educational jurisdictions under the terms of the *BCP Collaborative Course Development Project*:

- Black Gold Regional Schools
- Calgary Board of Education
- Edmonton School District No. 7
- Peace Wapiti School Division No. 76
- Pembina Hills Regional Division No. 7
- Red Deer Catholic Regional Division
- Rocky View School Division No. 41

Chemistry 20
Module 1: Chemical Foundations
Student Module Booklet
ISBN 978-0-7741-2994-7

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Teachers	✓
Administrators	
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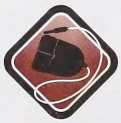
General Public	
Other	



You may find the following Internet sites useful:

- Alberta Education, **http://www.education.gov.ab.ca**
- Learning Resources Centre, **http://www.lrc.education.gov.ab.ca**
- Tools4Teachers, **http://www.tools4teachers.ca**

Exploring the electronic information superhighway can be educational and entertaining. However, be aware that these computer networks are not censored. Students may unintentionally or purposely find articles on the Internet that may be offensive or inappropriate. As well, the sources of information are not always cited and the content may not be accurate. Therefore, students may wish to confirm facts with a second source.

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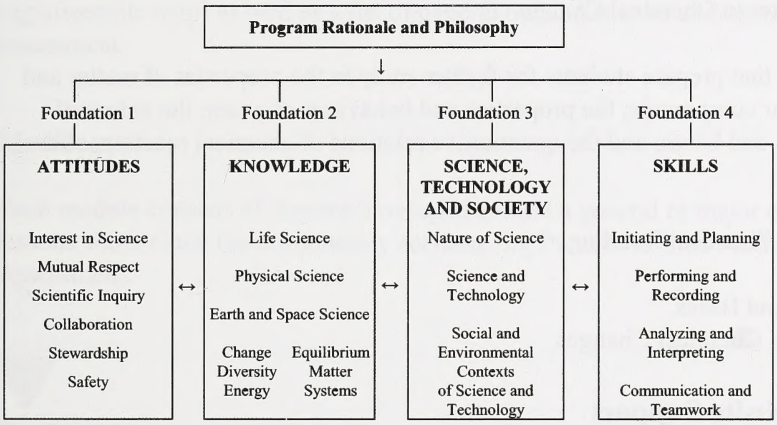
Chemistry 20

Welcome to Chemistry 20

In Chemistry 20 you will learn more than facts. You will be encouraged to develop positive attitudes and to acquire and use knowledge and skills in responsible ways. Your studies will lead you to achievements in each of the following four areas prescribed by the Alberta Program of Studies.



Foundation 1

Attitudes—*Students will be encouraged to* develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Foundation 2

Knowledge—*Students will* construct knowledge and understandings of concepts in life science, physical science, and Earth and space science and apply these understandings to interpret, integrate, and extend their knowledge.

Foundation 3

Science, Technology, and Society (STS)—*Students will* develop an understanding of the nature of science and technology, the relationships between science and technology, and the social and environmental contexts of science and technology.

Foundation 4

Skills—*Students will* develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

This course builds upon the scientific concepts from

Grade 8 Science, Unit A: Mix and Flow of Matter
Grade 9 Science, Unit B: Matter and Chemical Change
Grade 9 Science, Unit C: Environmental Chemistry
Science 10, Unit A: Energy and Matter in Chemical Change

Chemistry 20 is composed of four units that prepare students for further study in the properties of matter and chemical bonding of ionic and molecular compounds; the properties and behaviour of gases; the nature of matter in the context of solutions, acids, and bases; and the quantitative relations of chemical reactions. These units are

Unit A: The Diversity of Matter and Chemical Bonding
Unit B: Forms of Matter: Gases
Unit C: Matter as Solutions, Acids, and Bases
Unit D: Quantitative Relationships in Chemical Changes

Chemistry 20 Textbook and Website Support

Nelson Chemistry, Thomson Nelson

You will be using *Nelson Chemistry* as your textbook for this course. It will help you add depth to your understanding of the topics you study. You will find additional support at the textbook's online website, http://www.science.nelson.com/. Here, you can use unit pre-quizzes, web links, chapter highlights, study tips, research tools, and other opportunities for further learning.

About Chemistry 20

The learning model used in Chemistry 20 is designed to be engaging and to have you participate in inquiry and problem solving. You will actively interpret and critically reflect on your learning process. Learning begins within a community setting at the centre of a larger process of teaching and learning. You will be encouraged to share your knowledge and experiences by interaction, feedback, debate, and negotiation.

Components

This Chemistry 20 course has three main components. It consists of seven Student Module Booklets, seven Assignment Booklets, and the Chemistry 20 Multimedia DVD.

Course Structure

The course uses the following structure to connect you to the relevant curriculum and scientific concepts in Chemistry 20. These components are used consistently throughout the course and will help you in seeing the context and overall content of the program.

Unit

The units of study are identified in the Program of Studies. Units are defined by subject matter and are not limited by quantity of content or time of study. Each unit is comprised of modules (usually one for each general outcome), includes a general introduction and a visual representation of content structure (e.g., concept organizer/site map) as well as a list of general outcomes to be addressed, and includes a unit summary and assessment.

Module

Each module consists of content developed around a general or major outcome. Modules are comprised of lessons and include the introductory sections Big Picture, In This Module, and Module Summary and Assessment.

Big Picture

Big Picture provides a brief introduction to the module while connecting to your prior learning and personal knowledge. It refers to the essential questions of the module and invites you to reflect on the "big picture" within your own context.

Discuss

Discuss provides opportunities for you to interact with your peers and teacher. Discussion topics and collaborative activities should be independent of delivery mode, given the variety of technology access and delivery methods in schools.

Explore

Explore encourages you to investigate new concepts through preparation and presentation (Read), multimedia interactions (Watch and Listen), hands-on simulations (Labs), and explorative activities (Try This). Components within this section often do not follow a specific order. For example, you can do Watch and Listen after Try This or do Labs before Read.

Get Focused

Get Focused encourages you to focus on the task at hand and the outcomes to achieve. It includes a list of knowledge outcomes, STS outcomes, and/or skills outcomes. It prepares you for the upcoming lesson by providing a lesson rubric, a list of assessment items, and a list of required equipment and materials.

Going Beyond

Going Beyond gives you the choice of challenging and enriching your knowledge beyond the lesson.

Lab

Labs include hands-on activities with available equipment/materials and/or multimedia simulations of a lab.

Lesson

Each lesson consists of the main learning content from which you explore, reflect, and connect. The length of each lesson is defined by content that covers at least one measurable outcome.

Read

The Read component uses textual material to convey concepts to you. This material may appear directly within this component. Alternatively, it may be presented indirectly through another resource. For example, you may be sent to your textbook or provided with a link to a website.

Reflect and Connect

Reflect and Connect provides you with opportunities to check your understanding of concepts introduced in the lesson (Self-Check) and to make connections to prior learning and personal knowledge (Reflect on the Big Picture). It also provides you with opportunities to interact with your peers and your teacher through communication and collaboration (Discuss).

Reflect on the Big Picture

Reflect on the Big Picture, part of Reflect and Connect, provides connections to the Big Picture introduced at the beginning of the module. It connects and adds to the initial essential question(s) and situates the concepts of the lesson within the Big Picture context.

Summary

There are course, unit, module, and lesson summaries. All lesson summaries build toward the unit and course summaries and make connections to the Big Picture introduced at the module level. Each summary provides you with information about what you have accomplished.

Self-Check

Self-Check provides you with opportunities to check your understanding of new concepts learned in the lessons and to make connections to prior learning. You may be able to check your own work, or you may require teacher feedback.

Try This

Try This includes opportunities to practise and apply learned concepts outside of a lab environment. These can be simulations, questions, webquests, or other activities that provide you with a space to explore different ways of applying new concepts.

Watch and Listen

Watch and Listen includes both passive and interactive multimedia content (podcasts, videos, interactive Flash activities, etc.).

Visual Cues (Icons)

You will see icons throughout the course. These icons are clues regarding the type of activity you are about to begin.

Each unit in the course has a different colour theme, and the icons will change colour to match. For example, here are the four different colours of the Big Picture icon that appear in Units A to D, respectively.

Unit A

Unit B

Unit C

Unit D

The icons and their meanings are given.

Big Picture

Assessment

Summary

Get Focused

Read

Try This

Self-Check

Reflect and Connect

Explore

Reflect on the Big Picture

Going Beyond

Watch and Listen

Discuss

Lab

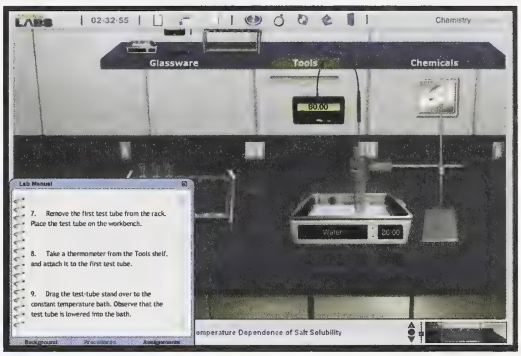
Reference (Data Tables)

In this course you will need numerical and scientific data for reference. Just inside the front cover of your textbook, *Nelson Chemistry*, is the periodic table of elements. In addition there are data tables at the very back of the textbook and in the textbook Appendices.

The Chemistry Data Booklet from Alberta Education also contains the reference data. You will be allowed to use a copy of the Data Booklet when writing the Chemistry 30 Diploma Examination. That is a good reason for becoming familiar with the Data Booklet. The Data Booklet can be downloaded from http://www.education.alberta.ca/admin/testing/diplomaexams.aspx.

Special Learning Activities: Labs and Simulations

This course includes chemistry experiments for you to perform. To avoid the need for specialized apparatus and chemicals, you will be provided with computer multimedia simulations to provide a hands-on experience. For example, you will have the opportunity to use simulations to examine the boiling points and melting points of substances, the behaviour of gases under varying pressures and temperatures, and the solubility of a substance at various temperatures.



Glossary

A chemistry glossary—an alphabetical list of chemistry terms and their meanings—is provided in this course. Your textbook, *Nelson Chemistry*, also has a glossary for you to refer to.

Lesson Answers (for students)

For many items, answers are provided through a "Check your work" link. Some items, especially assessment items, are to be marked by your teacher. For these items, submit your work to your teacher.

Using the Chemistry 20 Course Folder

The Chemistry 20 course folder serves as the organized collection of your work in Chemistry 20. It exhibits to others your efforts, achievements, self-reflection, and progress throughout the course. When you want to show your friends or family what you've been learning, your work is all there.

You will be expected to put all of your work into the course folder. If you are unsure of the process, your teacher will walk you through it. Throughout the course you will be asked to add things to the course folder.

In addition to being able to show others what you have done, the course folder lets you see your progress. It lets you see how your knowledge, skills, and understandings are growing. It also lets you review and annotate work you have already completed. You may find your course folder useful in preparing for tests and quizzes.

Periodically, you will be asked to share items from your course folder with your teacher. This is not always for grading, as often your teacher may use these items to learn more about you and your interests or as a way of tailoring other work assigned to you.

Technical Requirements

This course requires the following technical requirements.

Minimum System Requirements:

PC Compatible

- Intel(R) Pentium(R) III or AMD-K6(R)-2 processor-based computer
- 450 MHz CPU
- Microsoft(R) Windows(R) 2000/XP
- 512 MB RAM
- monitor capable of 1024 x 768 screen resolution and 16-bit colour
- 16-bit sound card and speakers
- 1x DVD-ROM drive (for print version)
- A printer is recommended.

Macintosh(R)

- Power Macintosh(R) G3
- 500 MHz CPU
- Mac OS(R) X
- 512 MB RAM
- monitor capable of 1024 x 768 screen resolution and thousands of colours
- 16-bit sound card
- 1x DVD-ROM drive (for print version)
- A printer is recommended.

Minimum Software Requirements*:

For All Platforms

- Adobe(R) Reader(R) 6.0 (Download from http://www.adobe.com/downloads/)
- Adobe(R) Shockwave(R) Player 8.5 (Download from http://www.adobe.com/downloads/)
- Adobe(R) Flash(TM) Player 7 (Download from http://www.adobe.com/downloads/)
- Microsoft(R) Office Excel(R) 2003
- Microsoft(R) Office Word 2003 (optional)
- QuickTime(R) Player 7.0 (Download from http://www.apple.com/quicktime/download)

For Windows(R) 2000/XP

- Microsoft(R) Internet Explorer 6.0 for Windows(R) (Download from http://www.microsoft.com/windows/ie/ie6/downloads/default.mspx) OR
- Mozilla(R) Firefox(R) 2 (Download from http://www.mozilla.org/download.html)
- Java(TM) 2 Platform Standard Edition (J2SE 1.4.1) (Download from http://java.sun.com/javase/downloads/index.jsp)

For Mac OS(R) X

- Safari(TM) 1.3
- Java(TM) 2 Platform, Standard Edition, version 1.4.1 for Mac OS(R) X (Download from http://apple.com/java)

* Please note that vendors may have a more current version of their players and/or plug-ins available, which you can download from their sites, than the minimum software requirements listed above.

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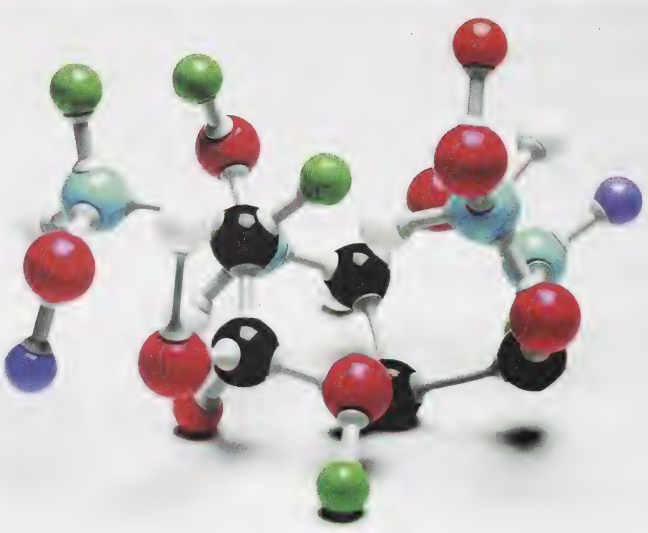
Chemistry 20

Unit A The Diversity of Matter and Chemical Bonding

Unit A Introduction

Concepts, models, and theories are often used to interpret and explain observations and to predict future observations. This unit relates theories about bonding to the properties of matter and develops explanations and descriptions of structure and bonding through scientific models. You will learn about the diversity of matter by investigating ionic and molecular substances.



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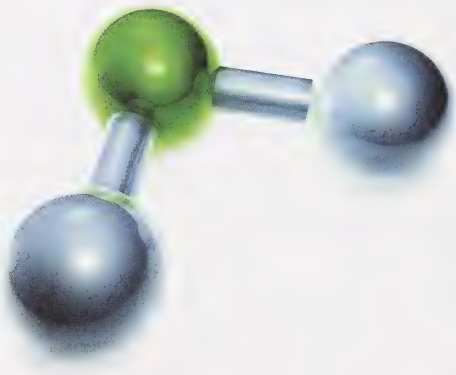

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This unit builds on concepts of matter, energy, and chemical change discussed in previous science courses. You will use graphing and measuring techniques learned in previous math courses as well. This unit will prepare you for several units in Chemistry 30, including thermochemical and electrochemical changes, and for when you begin to study organic chemistry.

The major outcomes for this unit are for you to be able to

- describe the role of modelling, evidence, and theory when explaining the structure, bonding, and properties of ionic compounds

- describe the role of modelling, evidence, and theory when explaining the structure, bonding, and properties of molecular substances

The overarching questions in this unit are

- What is the role of modelling, evidence, and theory in explaining and understanding the structure and properties of molecular substances?

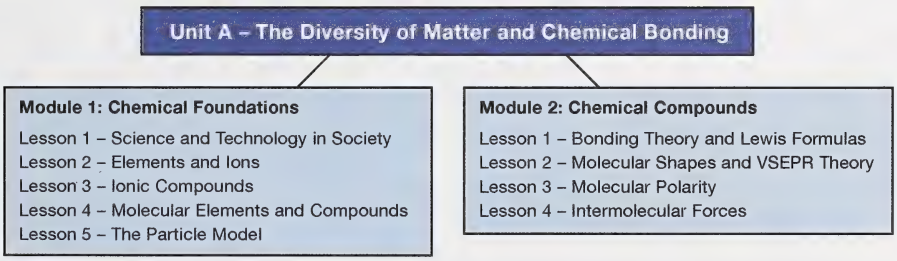
- What is the role of modelling, evidence, and theory in explaining and understanding the structure and properties of ionic compounds?

- Why do different substances have different melting and boiling points in addition to differences in other physical properties?

The major concepts developed in this unit are

- the use of science and technology in society
- the structure and properties of elements and ions
- the structure and properties of ionic compounds and molecular compounds
- chemical change and its relationship to the kinetic molecular theory
- bonding theory and Lewis formulas
- molecular shapes and VSEPR theory
- molecular polarity and intermolecular forces

Concept Organizer



Module Descriptions

Module 1—Chemical Foundations

Module 1.1 will examine fundamental science and chemistry concepts in the context of nuclear technology. What do you know about nuclear technology? What are the risks and benefits of nuclear technology? In this module you will gather evidence from a variety of reliable sources that represent a variety of perspectives on nuclear technology.

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The essential question that you will look at in this module is

- What is the importance of developing models, using empirical evidence, and developing theories to explaining and understanding the structure and properties of ionic compounds?

Module 2—Chemical Compounds

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In this module you will learn about chemical compounds and the forces within, and between them. You will learn about other types of chemical bonds and the effect they have on the properties of some substances, and how these properties are used to develop technologies that you might be using, but did not know it.

The essential question that you will look at in this module is

- How are models, empirical evidence, and theories used to explain and understand the structure and properties of molecular substances?

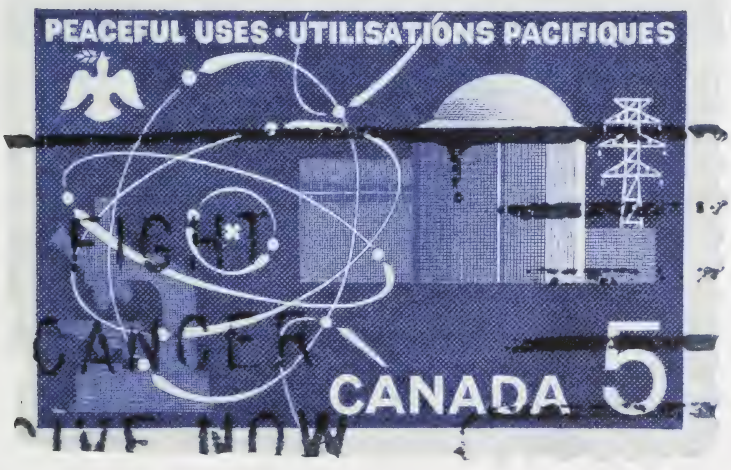
Module Introduction

Throughout Module 1 you will be examining fundamental science and chemistry concepts in the context of nuclear technology. You will examine

- science and technology in society
- **elements** and **ions**
- **ionic compounds**
- **molecular compounds**
- chemical change and the **kinetic molecular theory**

In the context of nuclear technology, the question addressed in Module 1 is as follows:

What are the roles of modelling, evidence, and theory when explaining and understanding the structure, bonding, and properties of ionic and molecular compounds?



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element: a pure substance that cannot be broken down into simpler chemical substances by any physical or chemical means; consists of only one kind of atom

ion: an entity with a net positive or net negative electrical charge due to the loss or gain of one or more electrons

ionic compound: a pure substance formed from the bond between a metal and a non-metal

molecular compound: a pure substance formed by covalently bonded non-metal atoms

kinetic molecular theory: the idea that the smallest entities of a substance—atoms, ions, or molecules—are in continuous motion, colliding with each other and objects in their path

Big Picture

What do you know about nuclear technology? Is there more to nuclear technology than bombs? Have you or someone you know ever had an X-ray, ultrasound, CT scan, or MRI? Have you ever heard of "The Manhattan Project," the "Trinity Test," or the "Cuban Missile Crisis"? What about the use of nuclear weapons during World War II or the incidents at Three Mile Island and Chernobyl? Do you, your family, or your community

have an opinion about nuclear technology? Do you know anyone who has been directly affected by nuclear technology? If so, was the experience positive or negative?

Use the Timeline located on your Chemistry 20 Multimedia DVD to view some important events in the history of nuclear **technology**.

technology: the skills, processes, and equipment required to manufacture useful products or to perform useful tasks

The history of nuclear power in Canada begins in the 1940s with the development of the ZEEP (Zero Energy Experimental Pile) reactor. On September 5, 1945, ZEEP became the first active nuclear reactor outside of the United States. Its purpose was to allow scientists to carry out nuclear experiments and to test the viability of nuclear power. Canada's experimentation with the ZEEP reactor led to the development of the CANDU (CANada Deuterium Uranium) reactor in the 1960s. In 2006, there were approximately 37 active CANDU reactors in countries around the world, including Canada, South Korea, China, India, Argentina, Romania, and Pakistan.

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In This Module

Lesson 1—Science and Technology in Society

This lesson will examine the relationships between science and technology. You will explore the methods of classifying and communicating knowledge, the importance of completing a risk-benefit analysis, and the importance of recognizing differing perspectives when studying a complex issue. You will use descriptions, tables, graphs, hypotheses, definitions, generalizations, and laws in your communication.

- What is the nature of science and technology, and what are the relationships between them?
- How can science-related societal, political, economic, ethical, and ecological issues be addressed?
- Can scientific knowledge lead to the development of new technologies, and can new technologies lead to or facilitate scientific discovery?

Lesson 2—Elements and Ions

This lesson will review the structure and function of the periodic table. You'll study atomic structure and the relationship among protons, neutrons, and electrons. You will then learn how atoms become ions and study how they form charged particles due to an imbalance of protons and electrons.

- From Science 10, can you identify elements and ions?
- How does scientific knowledge develop through hypothesizing, investigating, and collecting evidence?
- How do the observations and experimental work of many individuals lead to modern understandings of matter?

- Do theories develop as a result of the sharing of ideas by many scientists?
- What is the role of evidence in the development of the atomic model?
- Why is it important to have a questioning attitude and a desire to understand more about matter?
- How have Canadians contributed to the research?

Lesson 3—Ionic Compounds

This lesson will focus on ionic compounds, such as table salt (sodium chloride). Naming and writing formulas for ionic compounds is of critical importance in this lesson. You will examine the process of forming ionic compounds involving binary compounds, multi-valent metals, polyatomic ions, and hydrates. You will learn that ionic compounds are solids at room temperature and, if they are soluble in water, form conducting solutions. You will also study electronegativity and how it affects the formation of a chemical bond through the competition for bonding electrons.

- Can you recall the principles for assigning names to ionic compounds from Science 10?
- How does an ionic bond form?
- Why do formulas for ionic compounds refer to the simplest whole-number ratio of ions?
- What are valence electrons? What is electronegativity? What is an intramolecular force?

Lesson 4—Molecular Elements and Compounds

The focus in this lesson is on molecular elements and compounds, like sugar. They can be found in any state at standard conditions and, unlike ionic compounds, if they are soluble in water, they do **not** form conducting solutions. You will learn how to name formulas for molecular elements and compounds using the prefix system. You will study how they form as a result of two or more atoms sharing electrons. You will explore how the difference in electronegativity between two atoms helps identify the bond between the atoms.

- From Science 10, can you recall the principles for assigning names to molecular substances?
- How does the difference in electronegativity within a compound affect bonding?

Lesson 5—The Particle Model

This lesson compares and contrasts physical changes, chemical changes, and nuclear changes by examining the changes that occur to the particles involved.

- What is the particle model of matter?
- What is the kinetic molecular theory?
- What are the types of changes in matter, and what evidence is there that a chemical change has occurred?

Module Assessment

The assessment in this module consists of two (2) assignments, as well as a final module project.

- Lesson 2 Assignment
- Lesson 3 Assignment
- Module Project on Nuclear Technology

In Module 1 you will be required to complete a module project. You will be required to prepare a speech, letter, report, or multimedia presentation that promotes nuclear technology or speaks against nuclear technology. For more information, you can read "Appendix D: STS Problem Solving" on page 806 of your textbook.

A mark out of 5 will be given for each project component according to the following guidelines.

Score	Criteria
5 **Excellent**	The student demonstrates an **excellent** understanding of the **component** of the project and fully and correctly supports opinions using relevant facts and details. Statements made in the response are organized, unambiguous, and are supported explicitly but may contain a minor error or have minor omissions.
4 **Good**	The student demonstrates a **good** understanding of the **component** of the project and fully and adequately supports opinions using facts and details. Statements made in the response are unambiguous, mostly complete, mostly correct, but may contain errors.
3 **Satisfactory**	The student demonstrates a **basic** understanding of the **component** of the project. Statements made in the response may be disorganized, ambiguous, incomplete, and may lack support.
2 **Limited**	The student demonstrates a **limited** understanding of the **component** of the project. Statements made in the response lack details, clarity, and support.
1 **Poor**	The student provides one or more relevant but unconnected statements that address some aspects of the project.
0 **Insufficient**	The response is incorrect and/or totally off topic.

Your project will be assessed based on the following criteria.

Project Components	Weighting
clearly states a position and supports it by evaluating risk-benefit of nuclear technology	5
communicates ideas using appropriate strategies	5
considers complex issues from multiple perspectives	5
Demonstration of Specific Knowledge	**Weighting**
Lesson 2 Research • What isotope of uranium exists? • What isotope of uranium is used in the CANDU process? • What is half-life? • What is the half-life of the isotope of uranium used in a CANDU reactor? • How does the uranium used in a CANDU reactor exist in nature? What processes are used to prepare the uranium for use in a reactor? • What isotopes are produced as waste from a CANDU nuclear reactor? • How is waste material from a CANDU reactor stored and disposed?	5
Lesson 3 Research • How does the uranium used in a CANDU reactor exist in nature? What processes are used to prepare the uranium to be used in a CANDU reactor? • What concerns exist about the mining and the processing of natural sources of uranium? • How have uranium mining and extraction facilities affected communities?	5
Lesson 4 Research • What kind of radiation is classified as ionizing radiation? • What effect does ionizing radiation have on water? • Why is there concern about changes to matter as a result of exposure to ionizing radiation?	5
Research Skills	**Weighting**
appropriate selection of resources representing a range of viewpoints	5
proper citation of sources at the conclusion of the project (e.g., a bibliography)	5
	Total of 40 marks

Lesson 1—Science and Technology in Society

Get Focused

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Incorporating technology may have unforeseen consequences. During World War II, an insecticide called DDT was used to prevent insects from transmitting disease (specifically typhus and malaria). An unforeseen effect of using DDT was the large decline in raptor populations, such as the peregrine falcon, due to a weakening of their egg shells. DDT was banned in most developed nations in the 1970s and 1980s, and raptor populations are now recovering. This example demonstrates the importance of doing a risk-benefit analysis when considering the use of technology or a change to processes.

Even today, DDT is still used in many developing nations where malaria continues to be a problem. Malaria annually affects millions of people worldwide. Due to this, the benefit of using DDT to prevent malaria and save lives is given a greater priority than the risk posed to the environment and to sensitive bird populations.

In this lesson you will examine the relationships between science and technology. Pay particular attention to how the introduction of a technology might affect society. Recent concerns about climate change have focused attention on the possibility of using nuclear reactors for the production of electricity—even in Alberta. Such important decisions require careful consideration, often involving multiple perspectives. In this lesson you will review the different perspectives often considered when examining complex situations involving the application of technology.

Essential Questions

- What is the nature of science and technology, and what is their relationship?
- How should science-related societal, political, economic, ethical, and environmental issues be addressed?
- Can scientific knowledge lead to the development of new technologies? Can new technologies lead to or facilitate scientific discovery?

Assessment

In this lesson you will begin your module project. Create a folder on your computer in which you will store all your work during this course. For now, you can use this folder to store all your research and save any work you create as you complete the project. Later in the lesson you will receive more information about how to complete this part of the project. For additional information about the project, view the Module Summary and Assessment section.

The other questions in this lesson are not marked by the teacher; however, you should still answer these questions. The Self-Check and Try This questions are placed in this lesson to help you review important information and build key concepts that may be applied in future lessons.

After a discussion with your teacher, you must decide what to do with the questions that are not part of your assignment. For example, you may decide to submit to your teacher the responses to Try This questions that are not marked. You may decide to record the answers to all the questions in the lesson and place those answers in your course folder.

The choices you make about responding to the Self-Check and Try This questions will depend upon your learning style, your abilities in this subject, and your goals for the course.

Explore

People often use the terms *science* and *technology* interchangeably. Although these terms are related, they have different meanings.

theoretical knowledge: knowledge that explains and describes scientific observations in terms of non-observable entities

Science involves the study of natural products and processes with the purpose of describing, explaining, and predicting natural events. Science is **theoretical knowledge**, emphasizing ideas and conducting research.

Look at "Figure 1" from page 8 of the textbook. Is the process of problem solving in science linear, as depicted in the diagram, or does it proceed in another manner? Can you think of an example to support your opinion? You may wish to discuss this with your teacher.

Technology, on the other hand, focuses on the skills, processes, and equipment involved with manufacturing products and performing tasks. Technology is driven by cost, reliability, efficiency, and productivity. It focuses on practical applications and often utilizes a trial-and-error approach to find the best materials and methods.

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There are many cases where technology precedes science. The battery is a good example. Alessandro Volta is credited with inventing the battery in 1800, but scientists didn't understand the chemical reaction within the battery for another hundred years. In the case of Volta's battery, a new technology revealed the need for new science. In other situations, a new technology can enhance the existing science. The development of computer technology in the twentieth century has given scientists the means to explore scientific phenomena with great depth and speed.

Read

In your *Nelson Chemistry* textbook, read the following:

- "What Is Chemistry?" (page 9)
- "Classifying Knowledge" (pages 9 and 10)
- "Communicating Empirical Knowledge in Science" (pages 10 and 11)

This course is more than the study of theoretical knowledge and **empirical knowledge** about the natural world. A key component throughout this course will be making connections between science, technology, and societal issues as you learn about chemistry. There are many different perspectives that can be adopted when analyzing an STS connection: economical, ethical, ecological, political, scientific, societal, and technological. Read page 45 in your textbook to see a description of these perspectives.

empirical knowledge: knowledge gained through observation

Self-Check

Complete the Self-Check activity for Lesson 1, which can be found on your Chemistry 20 Multimedia DVD.

Discuss

Pick at least one of the topics given, and post your thoughts to the discussion area for your class.

Topic 1: Scientists are often characterized as being curious. What other characteristics, attitudes, or values do you think scientists require in order to be successful?

Topic 2: Aluminium is used extensively to make beverage cans. List some benefits and risks of this practice. Are there any alternatives that might have equal or better benefits and fewer risks?[1]

Topic 3: People often call society *technological* because lifestyles depend so heavily on human-made things. Can the lifestyle of Canada's original First Peoples (before 1500 CE) be considered non-technological? Explain your answer by giving examples.[2]

Read the postings from two other students who chose the same topic as you. Can you identify any different points that appear in their postings? Do the new points demonstrate that these students considered a different perspective while addressing the same topic as you? Can you identify which perspectives were used?

You may wish to record your answers to these questions on a copy of your posting. Place these answers in your Chemistry 20 course folder.

[1] Dr. Frank Jenkins, Jans van Kessel, Dick Tompkins and Dr. Oliver Lantz, *Nelson Chemistry Alberta 20-30* (Toronto: Nelson, a division of Thomson Canada Limited, 2007), p. 45. Reproduced by permission.

[2] Dr. Frank Jenkins, Jans van Kessel, Dick Tompkins and Dr. Oliver Lantz, *Nelson Chemistry Alberta 20-30* (Toronto: Nelson, a division of Thomson Canada Limited, 2007), p. 277. Reproduced by permission.

Reflect on the Big Picture

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For your module project you will prepare a speech, debate, report, short story, or multimedia presentation. This project will identify a position on the use of nuclear technology.Your presentation should identify and consider a variety of opinions about the use of nuclear technology (the **CANDU** reactor) used in Canada. As you develop your presentation, consider how nuclear technology is being viewed and what perspectives are being represented. Where possible, identify the influence that one or more perspectives have had on your position.

CANDU: Canadian Deuterium-Uranium reactor; a type of nuclear reactor

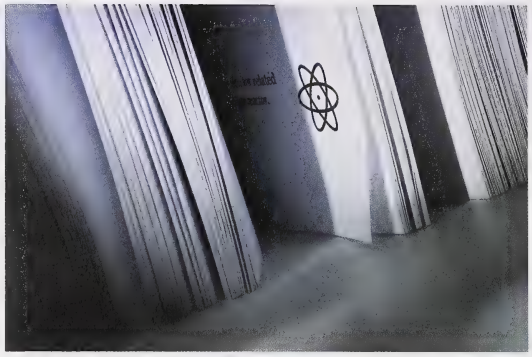
Assessment

You will now begin the project that forms part of the assessment for this module. In this part of the project you will conduct some research to identify some of the different perspectives that exists about the use of nuclear technology. For more information about the module assessment, refer to the Module Summary and Assessment section for this module.

Search the Internet for information about the use of nuclear technology.

While researching, keep the following in mind:

- Research multiple websites to obtain a wide variety of information and viewpoints.
- Evaluate the sites you visit to ensure they are reliable.
- Select appropriate resources, such as online encyclopedias, government websites, and post-secondary school sites.
- Document your sources in a bibliography.
- Respect the ownership and integrity of the information by ensuring your final project submission is in your own words.



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You may wish to use the search terms "Internet" and "searching smart" together to consult one of many Internet sites that provides information about efficient search strategies.

Suggestions and sources to help get you started on your research on the history of nuclear power in Canada and in other countries may be available from the archives of the Canadian Broadcasting Corporation. As you search through the archives, you may find information in text, audio, and video formats. You may wish to search the archives using terms that identify perspectives on the issue of nuclear power, such as

- "CANDU" (scientific and technological perspectives)
- "perspectives on nuclear power"
- "sale of CANDU technology" (economic perspective)
- "residents and CANDU reactor" (societal perspective)
- "nuclear exports" (technological, political, economic, and ethical perspectives)

You may also want to search for information about the use of nuclear power with an ecological perspective due to accidents at Chernobyl, Mayak, and Three Mile Island.

There have also been tremendous advances in medicine using nuclear technology, including X-rays, ultrasounds, CT scans, and MRIs.

You are encouraged to search other Internet resources, but remember that information can get very technical and may also express strong emotions. Keep the focus for your research clear as you collect information.

Lesson Summary

Reflect on the critical questions posed to you at the beginning of this lesson.

- What is the nature of science and technology, and what is their relationship?
- How can science-related societal, political, economic, ethical, and ecological issues be addressed?
- Can scientific knowledge lead to the development of new technologies? Can new technologies lead to or facilitate scientific discovery?

Throughout this course you will view the world through the eyes of a scientist. This will be done by following a cyclical problem-solving model in the quest to explain and predict the natural world. A key element of this model is the use of classification as an essential organizational tool to determine whether observations are qualitative or quantitative; to differentiate between direct and indirect knowledge; and to classify knowledge

as empirical or theoretical. When communicating ideas and findings with other people, you will use descriptions, tables, graphs, hypotheses, definitions, generalizations, and laws. The scientific method contributes one perspective to the decision-making process. As you have begun to see from your project work for this module, many opinions representing other perspectives can exist regarding complex issues.

Lesson Glossary

atom: the smallest entity of an element that is characteristic of that element

CANDU: Canadian Deuterium-Uranium reactor; a type of nuclear reactor

ecological perspective: a perspective, either pro or con, referring to the relationships among living organisms and the environment

economic perspective: a perspective, either pro or con, relating to the production, distribution, and consumption of wealth

empirical knowledge: knowledge gained through observation

ethical perspective: a perspective that bases decisions around accepted beliefs of a group

neutron: an uncharged subatomic particle present in the nuclei of most atoms

physical change: any change in the form of a substance in which the chemical composition does not change

political perspective: a perspective, either pro or con, relating to vote-getting actions or campaigning

scientific perspective: a perspective, either pro or con, relating to researching (describing, explaining, and predicting) natural and technological phenomena

societal perspective: a perspective that focuses on ways in which society functions and the ways in which people interact

technological perspective: a perspective, either pro or con, referring to the development and use of machines, instruments, and processes that have a social purpose

Lesson 2—Elements and Ions

Get Focused

Earth's crust is composed mainly of oxygen. The oxygen found in the crust is not in gaseous form as it is in the atmosphere. Instead, oxygen is a component found in solid compounds, such as rocks and minerals. Oxygen, like many elements, can exist in different forms. How does the structure of atoms differ when atoms of the same element have different forms? In this lesson you will review and extend your understanding of models of the atom and look at how these models are used to explain the different forms in which matter can exist. You will also see how these models relate to the availability of uranium, which is the energy source for nuclear reactors.

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Components of Earth's Crust	
oxygen	45.2%
silicon	27.2%
aluminium	8.0%
iron	5.8%
calcium	5.1%
magnesium	2.8%
sodium	2.3%
potassium	1.7%
other elements	1.9%

Essential Questions

- Can you remember how to identify elements and ions?
- How does scientific knowledge develop through hypothesizing, investigating, and collecting evidence?
- How do the observations and experimental work of many individuals lead to modern understandings of matter?
- Do theories develop as a result of many scientists sharing ideas?
- What role does evidence have in the development of the atomic model?
- Why is it important to have a questioning attitude and a desire to understand more about matter?
- How have Canadians contributed to nuclear research?

Module 1: Lesson 2 Assignments

In this lesson you will complete the Lesson 2 Assignment. You will also continue to work on your module project.

You must decide what to do with the questions that are not marked by the teacher.

Remember that these questions provide you with the practice and feedback that you need to successfully complete this course. You should respond to all the questions and place those answers in your course folder.

Explore

The organization of data into patterns or common characteristics helps scientists understand the material they are studying. In dealing with matter, elements are classified according to their **atomic numbers**. The atomic number indicates the number of protons (positively charged particles) found within the atom. Along with the atomic number, the elements are also categorized according to how they react. The result of this classification is the Periodic Table of the Elements.

atomic number: the characteristic number of protons in the nucleus of an atom of a particular element

The first periodic table was published in 1869 by Russian scientist Dmitri Mendeleev. He listed the data for the known elements—there were approximately 60 elements at that time—on file cards and set about arranging them in patterns. He left spaces in his arrangement for elements he believed were yet to be discovered. Because of the patterns within the periodic table, he was even able to predict the properties of these undiscovered elements. This held true as new elements were discovered and placed in the table.

The elements within the table are positioned according to **group** (or **family**) and **period**. Groups correspond to the vertical columns on the periodic table and are labelled from 1 to 18 across the top of the table. Periods denote the horizontal rows on the periodic table. There are seven periods on the table.

group: a set of elements with similar chemical properties; the elements in a vertical column in the main part of the periodic table; also called a family

family: see *group*

period: a horizontal row of elements in the periodic table whose properties gradually change from metallic to non-metallic from left to right along the row

Read

Read pages 14 to 16 in the textbook to review the organization of the periodic table. A version of the periodic table is also available in the Chemistry Databook. You will often use this version of the table as you work through this course and Chemistry 30.

Many versions of the periodic table are available on the Internet. Use the search terms "periodic table" and "interactive" to find versions that may even allow you to hear the pronounciation of element names.

As you work through this course you will use many values shown in the cells within the periodic table. In many cases, the values listed identify properties of each element and were used by Mendeleev and other scientists to construct and refine the position of elements on the periodic table.

Self-Check

SC 1. Use the Periodic Table Tutorial on your Chemistry 20 Multimedia DVD to check your understanding of the information contained on the periodic table. After you check your answers, you may wish to consult your teacher if there are gaps in your understanding.

Read

From your work in previous science courses you have learned that the atom has a dense nucleus that contains positively charged particles called **protons** and **neutral** particles called **neutrons**. The nucleus is orbited by negatively charged particles called **electrons**. Read pages 18 to the summary on page 23 to further review the atom's structure and scientific work that led to the current understanding of the structure.

Work through "SAMPLE problem 1.1" and the "Communication example" on page 22 of the textbook to review drawing atoms using a representation consistent with Bohr's theory.

proton: a positively charged subatomic particle found in the nucleus

neutral: having neither acidic nor basic properties; having a net charge of zero (electrically neutral)

neutron: an uncharged subatomic particle present in the nuclei of most atoms

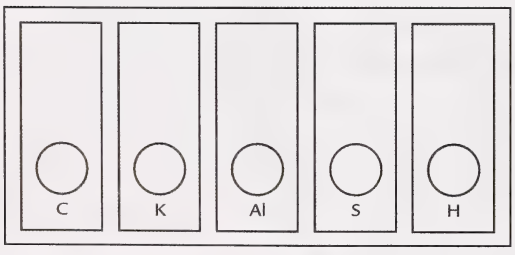
electron: a small, negatively charged subatomic particle; has a specific energy within an atom

Self-Check

SC 2. How many protons, neutrons, and electrons are found in the most common isotope of calcium?

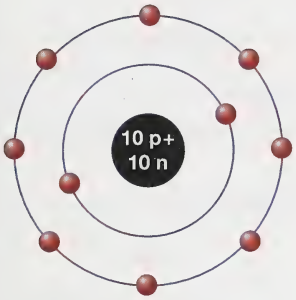
SC 3. What would a magnesium atom look like? Find magnesium on the periodic table, and sketch its energy-level diagram.

SC 4. Use the periodic table and the diagram for magnesium as references to complete the following energy-level diagrams.



Check your work in the Appendix.

Ions



Ne

Current theories about the atom's structure suggest that atoms have higher stability when their energy levels are filled to capacity with electrons.

Consider the **noble gases**. These elements are found in Group 18 on the periodic table and are known for their tendencies to be unreactive. As the theories you have studied to this point suggest, all noble gases have completely filled energy levels. For example, neon—which has 10 electrons surrounding the nucleus—has 2 electrons in the first orbital and 8 electrons in the second orbital. Both orbitals are completely filled. Because they are filled, neon is a stable gas and is very unreactive.

noble gas: elements listed in column 18 of the periodic table that share the property of very limited chemical reactivity

Discuss

Read "Formation of Monatomic Ions" on pages 23 and 24 of the textbook. After you have completed your reading, comment on the validity of the following statement:

"Atoms will gain or lose electrons to have an electron configuration like that of the nearest noble gas. When atoms gain or lose electrons, they become charged particles called *ions*. Energy level diagrams for ions can be drawn in a similar way as energy level diagrams for atoms. The difference is in showing a positive or negative charge on the ion."

Write a brief comment about if you feel this is an accurate statement or not. Share your comment with your teacher.

Watch and Listen

You may wish to view an animation that reviews the formation of ions in a more in-depth manner. Go to your Chemistry 20 Multimedia DVD and watch Watch and Listen 1.

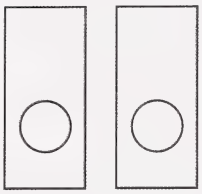
Another explanation for the formation of ions appears in the "Audio Walkthroughs" section of Lesson 1.4 on the textbook's website. If you do not already have access to this site, please contact your teacher.

Self-Check

SC 5. Draw the arrangement of protons, neutrons, and electrons for the phosphide ion.

SC 6. Draw the arrangement of protons, neutrons, and electrons for the beryllium ion.

SC 7. Draw the arrangement of protons, neutrons, and electrons for diagrams for the following ions.

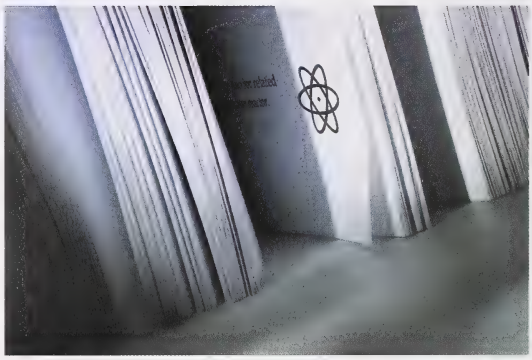


sodium Ion sulfide

Check your work with the answers in the Appendix.

Reflect on the Big Picture

The application of nuclear technology requires detailed knowledge about atoms and their structure. Research how uranium is naturally found and must be processed to create a "nuclear fuel" for the CANDU process.



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Module 1: Lesson 2 Assignments

Complete the Lesson 2 Assignment in the Module 1 Assignment Booklet.

Complete the following questions, which form the second part of your module project. Save a copy of your answers to your course folder. For more information about the module assessment, refer to the Module Summary and Assessment section for this module.

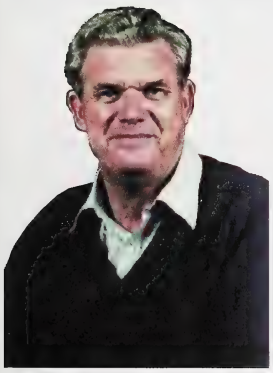
- What isotopes of uranium exist?
- What isotope of uranium is used in the CANDU process?
- What is a half-life?
- What is the half-life of the isotope of uranium used in a CANDU reactor?
- What isotopes are produced as waste from a CANDU nuclear reactor?
- How is waste material from a CANDU reactor stored and disposed?

While researching on the Internet, keep the following in mind:

- Ensure that you research multiple websites to obtain a wide variety of information and viewpoints.
- Evaluate the sites you visit, and ensure they are from a reliable source.
- Select appropriate resources, such as online encyclopedias, government websites, and post-secondary school sites.
- Document your sources in a bibliography.
- Respect the ownership and integrity of the information. Ensure that your final project submission is in your own words.

Going Beyond

Canadian Contribution



Courtesy of Stanford University

Richard Taylor was born in Medicine Hat, Alberta, in 1929. He attended the University of Alberta. Taylor was involved in the production of the Stanford Linear Accelerator Center in California. While working with two other scientists from the Massachusetts Institute of Technology (MIT), Taylor used the accelerator to dispel the belief that protons and neutrons were indivisible. His experiments in the late 1960s and early 1970s showed extremely small particles moving within protons and neutrons. These new particles were called *quarks*. In 1990, Richard Taylor was jointly awarded the Nobel Prize in Physics for his findings.

More information about Dr. Taylor's work is located in "Did You Know?" on page 23 of the textbook and in the "Weblinks" for Section 1.4 on the textbook website.

Lesson Summary

Reflect on the critical questions from the beginning of this lesson:

- Do you remember how to identify elements and ions?
- How does scientific knowledge develop through hypothesizing, investigating, and collecting evidence?
- How do the observations and experimental work of many individuals lead to modern understandings of matter?

- Do theories develop as a result of many scientists sharing ideas?
- What role does evidence have in the development of the atomic model?
- Why is it important to have a questioning attitude and a desire to understand more about matter?
- How have Canadians contributed to nuclear research?

In this lesson you reviewed the structure and function of the periodic table. You also reviewed basic atomic structure and the importance of protons, neutrons, and electrons in that structure. You extended your atomic knowledge and applied it to ions as well, understanding that they are charged particles due to an imbalance of protons and electrons. This lesson also illustrated how the observations and experimental work of many individuals led to the current understanding of the atom. This work has also allowed for the development of a process to use the energy from a nuclear change.

Lesson Glossary

electron: a small, negatively charged subatomic particle; has a specific energy within an atom

energy level: a specific energy an electron can have in an atom or ion

family: see *group*

group: a set of elements with similar chemical properties; the elements in a vertical column in the main part of the periodic table; also called a family

neutral: having neither acidic nor basic properties; having a net charge of zero (electrically neutral)

neutron: an uncharged subatomic particle present in the nuclei of most atoms

noble gas: elements listed in column 18 of the periodic table that demonstrate limited chemical reactivity

period: a horizontal row of elements in the periodic table whose properties gradually change from metallic to non-metallic from left to right along the row

proton: a positively charged subatomic particle found in the nucleus.

Lesson 3—Ionic Compounds

Get Focused

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Canada is one of the world's largest producers of uranium. Unfortunately, uranium does not naturally occur in a form usable in CANDU nuclear reactors, so it must be processed. In Lesson 2 you learned that many metals exist naturally in their ionic form and are often combined with non-metallic elements like oxygen. The mining and processing of uranium is a complex industry occurring in Canada and other locations in the world. Processing involves the conversion of uranium into other compounds that allows uranium to perform as a nuclear fuel.

In this lesson you will investigate questions about the structure and properties of ionic compounds, and you will relate these properties to considerations about uranium and the effect that processing uranium could have on the environment.

Essential Questions

- Can you recall the principles from Science 10 for assigning names to ionic compounds?
- How does an **ionic bond** form?
- Why do formulas for ionic compounds refer to the simplest whole-number ratio of ions?
- What are valence electrons? What is **electronegativity**? What is an **intramolecular force**?

ionic bond: the simultaneous attraction among positive and negative ions

intramolecular force: the relatively strong bonds or forces of attraction and repulsion within a molecule; typically covalent bonds

electronegativity: a value that describes the relative ability of an atom to attract a pair of electrons

Module 1: Lesson 3 Assignments

In this lesson you will complete the Lesson 3 Assignment in your Module 1 Assignment Booklet. You will also complete the third part of the module project.

Explore

Watch and Listen

Go to your Chemistry 20 Multimedia DVD and watch Watch and Listen 2. This video will introduce you to an ionic compound called sodium chloride—the chemical name for table salt—and introduce the chemical components of sodium and chlorine. Use this video to review the general properties of ionic compounds.

Ionic compounds are formed when a metallic element combines with a non-metallic element (e.g., NaCl).

Go to the Chemistry 20 Multimedia DVD and view Sodium Chloride, a video about the formation of NaCl. You may wish to "pause" the video and draw the representations of the sodium and chlorine atoms before they react and after they react. What happens, with respect to the arrangement of electrons around these two atoms, when the compound sodium chloride is made? Is this change consistent with what you learned in the previous lesson? Post a copy of your diagram and your answers to your class discussion area. Have a classmate review your answers. If you wish, revise your answer by including classmate comments. Place a copy of your revised work in your course folder.

Read

Ionic compounds are formed when electrons are transferred from a metal to a non-metal. As you saw in the most recent video, an ionic compound forms when the metal will lose electrons to have filled energy levels. Also, the non-metal will gain electrons to have filled energy levels. The transfer of electrons between metals and non-metals produces positively and negatively charged particles (ions) that attract each other to form an ionic bond.

An ionic bond is the result of an intramolecular force caused by the attraction of oppositely charged particles. You will examine four different types of ionic compounds:

- **binary ionic compounds**
- **multi-valent** metals
- **polyatomic ions**
- ionic **hydrates**

binary ionic compound: a compound that contains only two kinds of monatomic ions

multi-valent: the ability of an atom to exist as ions with different charges

polyatomic ion: a combination of two or more non-metal atoms that have a net charge not equal to zero

hydrate: a substance containing loosely bonded water molecules

Binary Ionic Compounds

Read "Binary Compounds" on page 29 of the textbook.

A review on this type of ionic compound follows.

Binary Ionic Compounds

Binary ionic compounds are composed of two kinds of **monatomic ions**. They are the simplest type of ionic compounds. The compounds are named by writing the name of the metal as it appears on the periodic table, followed by the name of the non-metal with the ending *-ide*.

monatomic ion: a positively or negatively charged particle formed from a single atom by the loss or gain of electrons; also known as a simple ion

Examples

NaCl	sodium chlor**ide**	K_2O	potassium ox**ide**
BaF_2	barium fluor**ide**	$CaCl_2$	calcium chlor**ide**
$AlBr_3$	aluminium brom**ide**	LiH	lithium hydr**ide**

Take a look at lithium fluoride by using a simplified diagram showing only electrons in the outermost energy level of each atom involved.

Lithium has one valence electron to give away. Li·	Fluorine has room for one more valence electron. ·F:
Lithium will give away the valence electron to the fluorine atom. Li· → ·F:	The lithium ion is now held to the fluoride ion through an ionic bond. $Li^+ [:F:]^-$

The formula of an ionic compound must have a net charge of zero. The positive charge of a lithium ion combined with the equal and opposite charge of a fluorine atom results in an electrically neutral compound.

Now take a look at beryllium fluoride.

You can see from the periodic table that the beryllium ion has a charge of 2+.

Beryllium has two valence electrons to give away. Be	Fluorine has room for one more valence electron. ·F:

A fluoride ion has a charge of 1^-. With a 1:1 ratio, you have Be^{2+} and F^-.

$$(2+) + (1-) = 1+$$

This is no good. This compound is not stable because it doesn't have a net electrical charge of zero. How do you fix this? You need to have two fluoride ions to obtain an overall charge of zero.

Since beryllium has **two** electrons to give away, two fluorine atoms are required to accept each electron. :F: ↘ Be ↙ :F:	There are now two fluoride ions held to the beryllium ion through ionic bonds. $[:F:]^- \ [Be]^{2+} \ [:F:]^-$

BeF_2 has a net charge of zero. The beryllium ion has a charge of 2+, and the two fluoride ions each have a charge of 1−. The end result is that the entire compound is electrically neutral.

There is a quicker way to write **chemical formulas** from the name. This involves writing the symbols of the ions first, and then simply swapping their superscripts and writing them as subscripts.

chemical formula: a series of symbols representing the atoms/ions, and their proportions, present in a pure substance

Example

Using the example of barium phosphide, write the two ions and include their charges.

Write the two ions and include their charges.

$Ba^{2+}\ P^{3-}$

Now, simply swap the superscripts and write them as subscripts. The formula now becomes Ba_3P_2.

Self-Check

SC 1. Complete each statement by providing the correct chemical name or chemical formula.

a. $MgBr_2$ is _____.
b. Al_2S_3 is _____.
c. The formula for beryllium nitride is _____.
d. The formula for potassium phosphide is _____.
e. CaO is the formula for_____.

Check your work in the Appendix.

Multi-Valent Metals

Read

The refining of uranium involves a variety of uranium compounds including U_3O_8, UO_3, and UO_2. How are these different oxides of uranium identified using names? Read "Multi-Valent Metals" on pages 29 and 30 of your textbook.

A review on this type of ionic compound follows.

Multi-Valent Metals

Multi-valent metals have more than one charge due to different electron configurations. When naming a compound containing one of these metals, you must indicate which charge (or form) is involved. The charge of the metallic ion is denoted using Roman numerals. The Roman numerals for numbers 1 to 7 are shown.

1 – I
2 – II
3 – III

4 – IV
5 – V
6 – VI
7 – VII

Ionic compounds containing multi-valent metals are named in the same way as binary ionic compounds, with the addition of a Roman numeral. After you write the name of the metal, you must indicate its charge using the appropriate Roman numeral in brackets. The name of the non-metal ion follows, and the ion still uses the ending *-ide*.

Example

Determine the name of MnO_2.

First, you need to determine the charge of the Mn ion (either 2+ or 4+). To figure out the charge on the multi-valent metal ion, use the charge and subscript of the non-metal ion. Recall that all ionic compounds have a net charge of zero.

Ions	Mn	O
Charge	?	2–
Subscript (Number of Each Ion in Formula)	1	1
Totals of Each Charge (Positive Must Equal Negative Charges)	$-2 = 1 \times (?)$ $? = +2$	$1 \times (-2) = -2$

The charge on the Mn ion in MnO is +2, and the name for the compound is manganese(II) oxide.

Is the name of the other oxide of manganese, MnO_2, manganese(IV) oxide?

You can determine the formula of an ionic compound containing a multi-valent metal in the same way you determined the formula for a binary ionic compound. Just remember that the Roman numeral indicates the charge on the multi-valent metal.

mercury(I) oxide $Hg^{+}\ O^{2-}$ gives Hg_2O.	mercury(II) oxide $Hg^{2+}\ O^{2-}$ gives HgO.
tin(II) chloride $Sn^{2+}\ Cl^{-}$ gives $SnCl_2$.	tin(IV) chloride $Sn^{4+}\ Cl^{-}$ gives $SnCl_4$.

Note that the more common form of a multi-valent metal is listed first on the periodic table (either the higher or the farthest left of the two charges given in the box on the periodic table). For example, Fe^{3+} is more common than Fe^{2+}. If the ion of a multi-valent metal is not specified in the description or in a question, you can assume Fe^{3+} is the most common ion.

Self-Check

SC 2. Complete each statement by providing the correct chemical name or chemical formula.

a. CuO is named _____.
b. The formula for mercury(II) nitride is _____.
c. The formula for tin(IV) sulfide is _____.
d. $FeCl_3$ is named _____.

Check your work with the answer in the Appendix.

Polyatomic Ions

Read "Compounds with Polyatomic Ions" on page 30 of your textbook.

If you want more of a review on this type of ionic compound, go to your Chemistry 20 Multimedia DVD and open the segment called Polyatomic Ions.

Self-Check

SC 3. Complete each statement by providing the correct chemical name or chemical formula.

a. The name for $BaCO_3$ is _____.
b. The name for $Ni_2(SO_4)_3$ is _____.
c. The formula for potassium dichromate is _____.
d. The formula for mercury(II) hydrogen carbonate is _____.
e. The name for NH_4MnO_4 is _____.
f. The formula for ammonium oxide is _____.

Check your work with the answer in the Appendix.

Ionic Hydrates

An ionic hydrate is formed when an ionic compound combines with water. The water is found within the ionic crystal, but it is not directly bonded to the compound itself. Ionic hydrates can be broken down into two parts. The first part is the portion containing the ionic compound and is written according to the rules you've learned in this lesson. The second part is often referred to as the **water of crystallization** and is named by writing "—water (X:Y)", where X is the **coefficient** in front of the ionic compound and Y is the coefficient in front of the water portion.

water of crystallization: water within a crystal, which is necessary for the maintenance of crystalline properties but capable of being removed by sufficient heat

coefficient: a number used to represent the quantity of molecules or the formula unit of a substance; a number that precedes a chemical formula

Read

Read the section titled "Ionic Hydrates" on page 31 of your textbook to see examples of the naming system used for this type of ionic compound.

Self-Check

SC 4. Complete this table.

Chemical Name	Chemical Formula
	$Na_2SO_4 \cdot 10H_2O$
calcium hydrogen phosphate–water (1/2)	
	$BaCl_2 \cdot 2H_2O$
sodium carbonate–water (1/10)	

Check your work with the answer in the Appendix.

Read

Read pages 78 to 80 in the textbook, up to "Table 1."

Try This

Prepare a list of new terms introduced in the pages from the textbook that you just read. Add their definitions. Prepare a concept map or another form of graphic organizer of the new terms introduced and how they are related to one another. You may wish to add in familiar terms like *energy level*, *anion*, *cation*, and *ion formation* into your organizer to make connections.

Discuss

Show your organizer to your teacher or to other students in your class to see if they can understand how you feel these concepts are related. Place a copy of your concept map in your course folder. You may wish to revise it based on the feedback you get from other people or from what you learn later in this module.

Electronegativity

Read

Read "Electronegativity" on page 81 of your textbook. What sort of information did Linus Pauling use to develop his scale of electronegativities? Are electronegativities measurable values or a representation?

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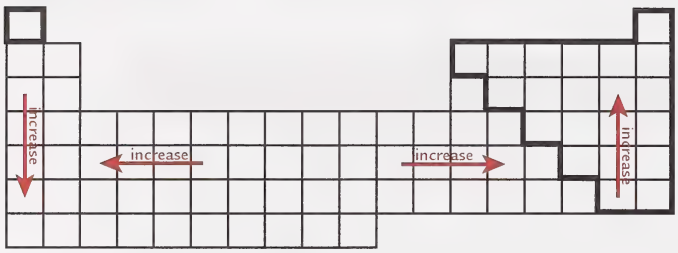
The "Reactivity of Elements" image illustrates the general reactivity trends on the periodic table, with the exception of the noble gases.

Reactivity of Elements



Try This

Identify where the highest and lowest values for electronegativity occur on the periodic table. Is the pattern for the reactivity of elements similar to the location of elements with high and low electronegativities?

Discuss

Can you suggest why there may there be a relationship between an element's reactivity and its electronegativity? Share your thoughts with your teacher or your classmates.

In Module 2 you will learn more about how to use electronegativities as you study covalent bonds.

You'll find the precise electronegativity of each element listed on the periodic table.

Read

How does electronegativity relate to the formation of ionic bonds? Read "Ionic Bonding" on page 83 of your textbook.

Self-Check

SC 5. Go to your Chemistry 20 Multimedia DVD and open Self-Check 5. Use the information on the periodic table to complete the table.

Watch and Listen

Earlier in Lesson 3 you watched video clips describing the formation of sodium chloride. The following video clips can be found on your Chemistry 20 Multimedia DVD. This series of video clips will help you understand what influence the ionic bond between particles has on other ions. This results in the formation of a crystal lattice and a chemical ratio for sodium chloride.

- Watch the Formation of NaCl video (NaCl Part 1).
- Find out why NaCl is a 1:1 ratio (NaCl Part 2).
- Watch the video Magnesium Oxide, which illustrates the formation of magnesium oxide. Does magnesium oxide form a crystal lattice with a similar structure to a crystal of sodium chloride? Is the chemical ratio between the magnesium ion and oxide ion also similar to the ratio between sodium and chloride ions?

Try This

Recall from Science 10 that all ionic compounds are solids at room temperature. These compounds have high boiling points due to the strong attractions within their crystal lattice. You also know that ionic compounds produce conducting solutions if they are soluble in water.

solubility: the concentration of a saturated solution at a specified temperature

The multimedia segment "Chemistry Mystery Lab" (on your Chemistry 20 Multimedia DVD) has you solving a puzzling problem in a chemistry lab. This problem can be solved by using knowledge about ionic compounds and **solubility**. To review solubility, including how to use the solubility table, read page 61 in your textbook. In the applet, you will be presented with four beakers. Each beaker contains an unknown solid. You'll see four identifying labels that have fallen off the beakers. In this activity you will use your knowledge of ionic compounds and information about the melting points of

these substances to match the label with the correct beaker. You will need to search the Internet to gather this data.

Discuss

Take a look through your home or school to see if you can identify some ionic compounds found within common items. Try looking at food and beverage ingredients or on the labels of cleaning supplies. On the bulletin board, post one example of an ionic compound that you found. Ensure you indicate the name of the compound, the chemical formula of the compound, and the substance you found it in.

Module 1: Lesson 3 Assignments

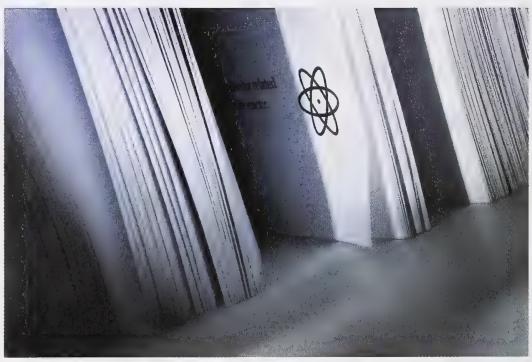
Complete the Lesson 3 Assignment in the Module 1 Assignment Booklet. Save a copy of your answers to your course folder.

Reflect on the Big Picture

Assessment

Continue working on your module project by researching answers to the following questions. Save a copy of your answers to your course folder. For more information about the module project, refer to the Module Summary and Assessment section for this module.

- How does the uranium used in a CANDU reactor exist in nature? What processes are used to prepare it for use in a CANDU reactor?
- What concerns exist about the mining and the processing of natural sources of uranium?
- How have uranium mining and extraction facilities affected communities?



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While researching the Internet, keep these guidelines in mind:

- Ensure that you research multiple websites to obtain a wide variety of information and viewpoints.
- Evaluate the websites you visit, and ensure they are from a reliable source.
- Select appropriate resources, such as online encyclopedias, government websites, and post-secondary school websites.
- Document your sources in a bibliography.
- Respect the ownership and integrity of the information. Ensure your final project submission is in your own words.

Lesson Summary

Reflect on the essential questions posed to you at the beginning of this lesson:

- Do you recall the principles from Science 10 for assigning names to ionic compounds?
- How does an ionic bond form from the simultaneous attraction of oppositely charged ions?
- Why do formulas for ionic compounds refer to the simplest whole-number ratio of ions?
- What are valence electrons? What is electronegativity? What is an ionic bond? What is an intramolecular force?

Use what you have learned during this lesson to answer these questions. If you record your answers, place a copy of them into your chemistry folder along with your other completed lesson work.

Ionic compounds surround you. They are formed when a metal transfers one or more electrons to a non-metal. Ionic compounds may involve multi-valent metals, polyatomic ions, and hydrates. These compounds are solid at room temperature and, if soluble in water, form conducting solutions. In this lesson you reviewed the rules for naming and identifying four different types of ionic compounds. You learned the importance of maintaining electrical neutrality in an ionic compound and determined the ratio of ions that yields a net charge of zero. Finally, you studied electronegativity and how it affects the formation of a chemical bond through competition for bonding electrons.

Lesson Glossary

binary ionic compound: a compound that contains only two kinds of monatomic ions

chemical formula: a series of symbols representing the atoms/ions, and their proportions, present in a pure substance

coefficient: a number used to represent the quantity of molecules or the formula unit of a substance; a number that precedes a chemical formula

compound: a pure substance that can be separated into its elements by heat or electricity; a substance containing atoms/ions of more than one element in a definite fixed proportion

electronegativity: a value that describes the relative ability of an atom to attract a pair of electrons

hydrate: a substance containing loosely bonded water molecules

intramolecular force: the relatively strong bonds or forces of attraction and repulsion within a molecule; typically covalent bonds

ionic bond: the simultaneous attraction among positive and negative ions

monatomic ion: a positively or negatively charged particle formed from a single atom by the loss or gain of electrons; also known as a simple ion

multi-valent: the ability of an atom to exist as ions with different charges

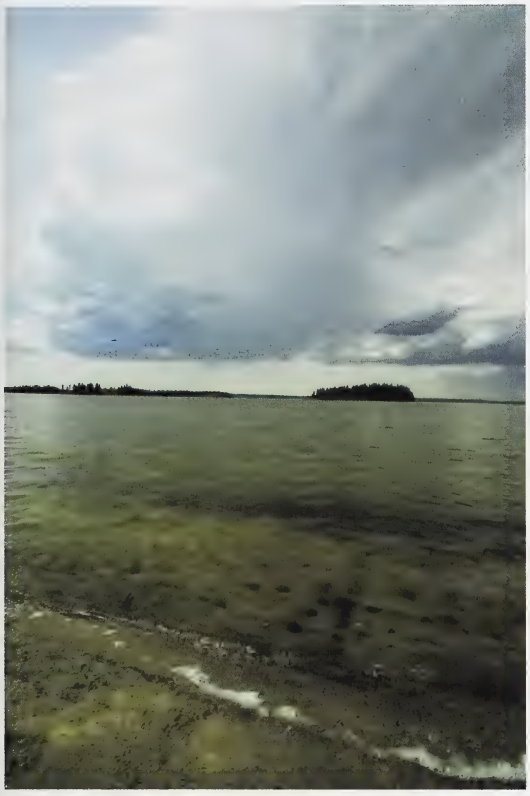
polyatomic ion: a combination of two or more non-metal atoms that have a net charge not equal to zero

solubility: the concentration of a saturated solution at a specified temperature

water of crystallization: water within a crystal, which is necessary for the maintenance of crystalline properties but capable of being removed by sufficient heat

Lesson 4—Molecular Elements and Compounds

Get Focused



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Picture yourself sitting on a quiet beach in July. It's hot, and the sky above you is a crystalline blue. On the horizon you can see clouds building up, maybe hinting of a thunderstorm later in the evening. A light breeze blows and cools your skin. And then it's still and hot again. You grab your glass of cold water that still contains a few remaining ice cubes. The glass has condensation droplets all over it; so you rub the glass on your forehead to try to cool off. You realize that this drink isn't going to cool you off for very long, so maybe it's time to go into the water.

Water is perhaps the most important **molecule**. Without water, there would be no life on Earth. Your body is made up of between 60% and 70% water. Water is a molecule produced by the chemical joining of two hydrogen atoms to a single oxygen atom. Scientists have explained this kind of bond as a sharing of electrons between atoms.

> **molecule:** an entity consisting of a group of non-metal atoms held together by covalent bonds

Sharing electrons may occur between the same (molecular elements, including elements that exist in a pure form in diatomic and polyatomic groups) or different non-metal atoms (molecular compounds). You may recall from your study in Science 10 that many molecular compounds are named using a prefix-naming system, whereas the names of other molecular compounds must be memorized. Molecular elements and compounds can be found in solid, liquid, and gaseous form at standard ambient temperature and pressure (SATP) and do not form conducting solutions. Is there a relationship between the properties of water, and other molecular compounds, and this type of bonding?

Essential Questions

- From Science 10, can you recall the principles for assigning names to molecular substances?
- How does the difference in electronegativity within a compound affect bonding?

Module 1: Lesson 4 Assignments

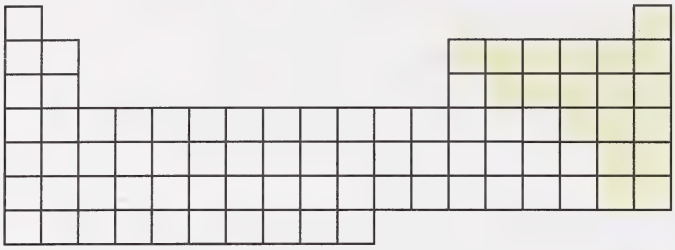
In this lesson you will complete the Lesson 4 Assignment in the Module 1 Assignment Booklet. You will also complete the fourth part of the module project.

You must decide what to do with the questions that are not marked by your teacher.

Remember that these questions provide you with the practice and feedback that you need to successfully complete this course. You may decide to respond to all the questions and place those answers in your course folder.

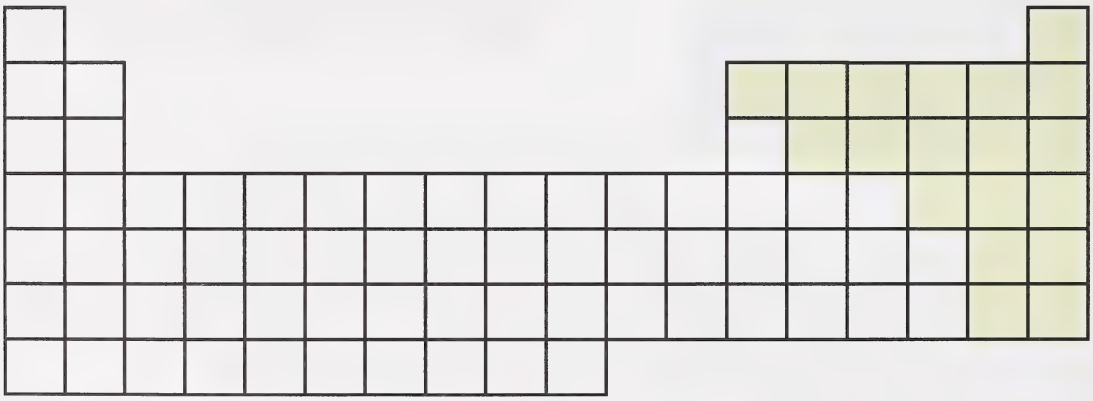
Explore

Molecules are formed when two or more non-metallic elements share electrons.



Self-Check

SC 1. Can you identify the location of the non-metallic elements on the periodic table representation? You can check your answer by referring to page 14 of your textbook.



SC 2. Molecules can be classified into two categories: molecular elements and molecular compounds. Can you identify the location of the molecular elements on the periodic table representation?

Check your work with the answer in the Appendix.

Naming Molecular Elements

Read

Read page 33 of the textbook and page 34 to the end of "Summary" to review the recognition and naming of molecular elements and the procedure for naming molecular compounds. Attempt Self-Check questions 3 and 4.

The information that follows is provided if you feel that you need further review.

Additional Review of Molecular Compounds

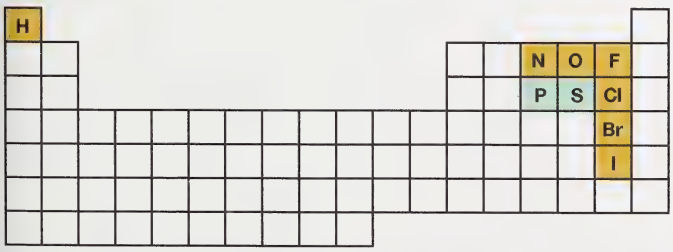
The molecular elements are bonded together as pairs (diatomic elements) or in groups of three, four, or eight (polyatomic elements). There are ten molecular elements that you need to memorize. Seven are diatomic molecular elements. This means they are found as pairs of atoms when in their natural state. These elements include

- nitrogen $N_2(g)$
- oxygen $O_2(g)$
- fluorine $F_2(g)$
- chlorine $Cl_2(g)$
- bromine $Br_2(l)$
- iodine $I_2(s)$
- hydrogen $H_2(g)$

Polyatomic elements include the following:

- phosphorus, found in nature as $P_4(s)$
- sulfur, found in nature as $S_8(s)$
- oxygen, in the form of ozone, $O_3(g)$

One way to remember the seven diatomic elements is to start at element 7 (nitrogen) on the periodic table, and trace a "7" (move right to fluorine and then down to iodine). Counting the elements in the "7" shape, you will find six elements. The seventh is hydrogen—it is way up in the top left-hand corner of the periodic table.



Another way to remember the diatomic elements is that they all end in either *-ine* (fluorine, chlorine, bromine, iodine) or *-gen* (hydrogen, nitrogen, oxygen). For the polyatomic elements, you may find it helpful to remember that phosphorus and sulfur are found beneath the top part of the "7" shape.

Describing and Naming Molecular Compounds

Molecular compounds are composed of at least two different non-metals. Examples of molecular compounds are water (H_2O), glucose ($C_6H_{12}O_6$), carbon dioxide (CO_2), and propane (C_3H_8).

Naming binary molecular compounds requires the use of prefixes to indicate the quantity of particular atoms within the compound. Molecular compounds involving nitrogen and oxygen provide excellent examples of how the naming system is applied.

N_2O_5 = dinitrogen pentaoxide
N_2O_4 = dinitrogen tetraoxide

In these two examples, prefixes must be used for both nitrogen and oxygen since they both have subscripts. The ending for a molecular compound is *-ide*; so, the second atom name must change to accommodate this.

NO_2 = nitrogen dioxide
Nitrogen does not have a subscript, so no prefix is required. Oxygen does have a subscript and, therefore, requires a prefix.

NO = nitrogen monoxide
Nitrogen does not have a subscript, so no prefix is required. Oxygen does not have a subscript either; but since it comes second, it must be written with the prefix *mono-*.

In this course you must memorize the listed prefixes.

Number of Atoms	Prefix
1	mono-
2	di-
3	tri-
4	tetra-
5	penta-
6	hexa-
7	septa-
8	octa-
9	nona-
10	deca-

These guided examples will give you further insight into naming molecular compounds.

Example

What is the name of N_2O_7?

There are two nitrogen atoms and seven oxygen atoms. Two atoms are represented by the prefix *di-*; so, the first part of the name is dinitrogen. Seven atoms are represented by the prefix *septa-* and, since oxygen is the last element in this formula, it is named oxide. This means the second part is named septaoxide. Therefore, N_2O_7 is dinitrogen septaoxide.

Example

What is the name for CCl_4?

Notice that there is one carbon atom and four chlorine atoms. Since there is only one carbon atom and it is the first atom in the formula, the first part of the name is simply carbon (no *mono-* prefix). Four chlorine atoms are represented by tetrachloride. Therefore, CCl_4 is carbon tetrachloride.

To write the formula from the compound name, reverse the process.

Example

What is the chemical formula for trisulfur hexaiodide?

The prefix *tri-* indicates that there are three atoms of sulfur. The prefix *hexa-* indicates there are six atoms of iodine. Therefore, the chemical formula is S_3I_6.

Unlike ionic compounds, molecular compounds are not written with the lowest possible ratio. The following example illustrates why:

- C_2H_2 is commonly called acetylene and is used in welding.
- C_6H_6 is commonly called benzene and is used as an industrial solvent.

These are two very different molecular compounds that would both reduce to CH in the simplest ratio. If you found a container labelled CH, how would you know what it is? Remember that ionic compounds reduce to the simplest ratio but molecular compounds do not.

You may have noticed that states have not been discussed when dealing with molecular compounds. States of molecular compounds do not follow simple rules and may be found in solid, liquid, and gaseous states at SATP. Other than memorizing the states of common molecular compounds, there is no easy way to determine their states.

Self-Check

SC 3. State the name of the following substances.

a. CO
b. P_4O_{10}
c. I_2

SC 4. State the chemical formula for the following substances.

a. dinitrogen tetraoxide
b. carbon disulfide
c. fluorine

Check your work with the answer in the Appendix.

Read

The prefix naming system is only used for a limited number of molecular compounds. There are millions of molecular compounds that cannot be named using this system, for example, those composed of more than two elements. Other naming systems or memorized common names are used to name these other molecular compounds.

Review "Table 3" on page 34 of your textbook. You may wish to make a copy of this table for your notes and memorize it, as these substances will often be referred to during this course and also in Chemistry 30.

Electronegativity

In Lesson 3 you were introduced to the concept of electronegativity. What effect does a difference in the attraction for the shared electrons between atoms participating in a covalent bond have on the bond and on the molecule that results from these bonds?

In the textbook, read "Electronegativity and Bond Polarity" on pages 99 and 100. Work through "SAMPLE problem 3.4" on page 100.

Self-Check

SC 5. Complete "Practice" problems 9 and 10 on page 100 of the textbook.

SC 6. Prepare a chart that summarizes the two types of covalent bonds, what distinguishes each type of bond, and two examples of each type of bond.

Check your work with the answer in the Appendix.

Discuss

Copy the table below. In the third column, write a justification that explains the type of bond formed in each of the electronegativity differences presented. Use your class discussion area to share your completed table with your classmates. Look at the tables of at least two other classmates. Are similar justifications made by the other students? You may wish to revise your justification. Once your table is complete, place a copy of it in your chemistry folder.

Electronegativity Difference	Type of Bond Formed	Justification for Type of Bond Formed
0	non-polar covalent	
greater than zero to 1.6	polar covalent	
greater than 1.6 to 2.1	• ionic if a metal is involved • polar covalent if no metal is involved	
greater than 2.1	ionic	

Module 1: Lesson 4 Assignments

Complete the Lesson 4 Assignment in the Module 1 Assignment Booklet. Save a copy of your answers to your course folder.

Reflect on the Big Picture

Assessment

Complete the questions below as the fourth part of your module project. As you have found in the other lessons, these questions allow you an opportunity to consider the concepts you have learned in this lesson, but within a different context. Save a copy of your answers to your course folder. For more information about the module project, refer to the Module Summary and Assessment section for this module.

One of the greatest concerns about the use of nuclear power is possible exposure to ionizing **radiation**. For the final piece of research for your project, you will need to learn more about ionizing radiation. Your research should find answers to the following questions:

radiation: energy released or transmitted in the form of rays, waves, or particles

- What kind of radiation is classified as ionizing radiation?
- What effect does ionizing radiation have on water?
- Why is there concern about changes to matter as a result of exposure to ionizing radiation?

Lesson Summary

Reflect on the critical questions asked at the beginning of this lesson:

- From Science 10, can you recall the principles for assigning names to molecular substances?
- How does the difference in electronegativity within a compound affect bonding?

Molecular elements and molecular compounds can be found in any state at SATP and, if they are soluble in water, they do not form conducting solutions. You reviewed the principles for naming molecular compounds using the prefix system and recognized that the names of some common molecular compounds have to be memorized. You also reviewed how to write formulas for molecular elements and compounds. You learned that molecular compounds result from two or more atoms sharing electrons. You also discussed electronegativity and how the difference in electronegativity between two atoms influences the characteristics of the bond between the atoms (e.g., ionic, polar covalent, or non-polar covalent).

Lesson Glossary

molecule: an entity consisting of a group of non-metal atoms held together by covalent bonds

radiation: energy released or transmitted in the form of rays, waves, or particles

Lesson 5—The Particle Model

Get Focused

Harnessing nuclear energy involves many changes for matter. As you have already learned in this module, chemical change must occur to process uranium from its ore into the nuclear fuel within a reactor. Certain isotopes of uranium undergo **nuclear change** as they become converted into other types of atoms and release radiation. The radiation released is used to heat water to produce steam, an example of a third type of matter change—a physical change. What is common to all of these kinds of change? How are each of these kinds of changes unique? Scientists often use models and theories to explain events that are not observable. In this lesson you will not only learn about the particle model for matter and the kinetic molecular theory, but you will discover how they can be used to explain matter changes described in this module.

nuclear change: a process that causes an alteration to the composition of an atom's nucleus

Essential Questions

- What is the particle model of matter?
- What is the kinetic molecular theory?
- What are the types of changes in matter, and what evidence is there that a chemical change has occurred?

Assessment

In this lesson you will complete the module project investigating nuclear energy.

You must decide what to do with the questions that are not marked by your teacher.

Remember that these questions provide you with the practice and feedback that you need to successfully complete this course. You may decide to respond to all the questions and place those answers in your course folder.

Explore

Changes in Matter and Energy

Throughout your study of chemistry, you have used the particle theory, which is an explanation of the properties of matter being composed of tiny particles. In this lesson you will explore physical, chemical, and nuclear changes and use your knowledge of the particle theory to discuss their similarities and differences.

Physical Changes

Try This

Use the Internet to locate information about the particle theory. How does this theory explain the different states in which matter can exist? In terms of the particles involved, how are the molecules of H_2O in ice, water, and steam different? How are these particles the same? Summarize your answers in a chart. You may wish to share a copy of the chart with your teacher to verify your understanding.

As you learned from your comparison of the arrangement of particles in the different states of matter, the change from one state to another (**phase change**) does not involve the breaking of chemical bonds. During a phase change, no new substances are formed. There is just a rearrangement of the particles involved. In order to cause such a rearrangement, energy is used. Energy is required to change the level of motion of the particles to such an extent that they can overcome forces between other particles. In Module 2 you will learn more about intermolecular bonds within a substance and their effects on physical properties of matter. These effects may include melting and boiling temperatures. Compared with other changes in matter, phase changes involve relatively small amounts of energy.

phase change: a change of a substance from one physical state to another

A change from a solid to a liquid, a liquid to a gas, or a solid to a gas is a phase change.

endothermic process: a change in matter that requires an input of energy to occur

exothermic process: a change in matter that releases energy when it occurs

The table lists the equations involved in the phase changes of one mole of water and the energy associated with those changes. When energy is absorbed (**endothermic process**), it is written on the left-hand side of the equation (the reactant side). When energy is released (**exothermic process**), it is written on the right-hand side of the equation (the product side).

Phase change from solid to liquid:	Phase change from liquid to solid:
$H_2O(s) + 6.01\ kJ \rightarrow H_2O(l)$	$H_2O(l) \rightarrow H_2O(s) + 6.01\ kJ$

Phase change from liquid to gas:	Phase change from gas to liquid:
$H_2O(l) + 40.65\ kJ \rightarrow H_2O(g)$	$H_2O(g) \rightarrow H_2O(l) + 40.65\ kJ$

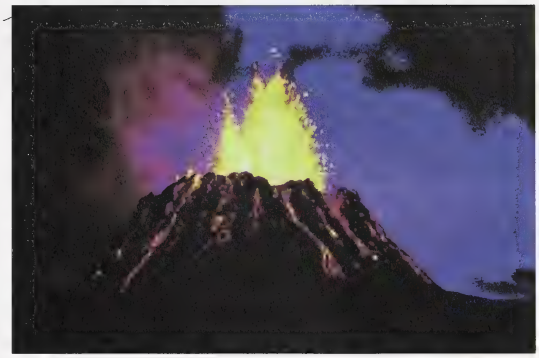
How do these reactions demonstrate that a change in matter does not affect the covalent bonds in the water molecule?

Try This

Observing Evidence of a Chemical Change—Volcano!

Volcano Dough

In a large mixing bowl, combine 1.5 L (6 cups) of flour, 500 mL (2 cups) of salt, 60 mL (4 tablespoons) of cooking oil, and 500 mL (2 cups) of warm water.



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Creating the Volcano

Place a small soft-drink bottle in the middle of a cookie sheet and use the volcano dough to build a volcano around the bottle. Be careful not to drop dough inside the bottle.

Eruption

- Fill a 600-mL soft-drink bottle about three-quarters full with warm water.
- Add some red food colouring to make the lava look real.
- Add about 6 drops of dish soap to the soft-drink bottle to help the lava bubble.
- Add 30 mL (2 tablespoons) of baking soda (not baking powder) to the solution in the soft-drink bottle.
- Once you're ready, add enough vinegar—approximately 100 mL—to start a vigorous reaction. Watch the eruption that follows!

When the reaction slows, you can add more vinegar to make the volcano erupt again. The volcano can be made to erupt several more times by adding more vinegar over the course of 15 to 20 minutes. The reaction taking place is between the baking soda and the vinegar, which produces carbon dioxide gas and increases the pressure in the bottle to cause the eruption. Have fun!

Read

intermolecular: existing or acting between molecules

Chemical reactions involve the breaking of bonds within reactant molecules, a complete rearrangement of the atoms, and the forming of product molecules that consist of bonds with atoms different than those in the reactant molecules. Therefore, a chemical change involves a change in intramolecular bonds in matter. Intramolecular bonds, like the ionic and covalent bonds you have studied in this module, are much stronger than **intermolecular** bonds. Therefore, in most cases, a chemical change involves a larger energy change than a physical change. In many cases, chemical changes are difficult or impossible to reverse. In a chemical change, new substances are formed with different properties than those of the starting materials. Most of your study in Chemistry 20 will focus on chemical changes.

Self-Check

SC 1. The balanced chemical reaction for the combustion of propane in a small camp stove is shown below.

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$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g) + 2220\ kJ$$

a. How does this reaction demonstrate that the change in matter affects the covalent bonds in the propane and oxygen molecules?
b. Is the combustion of propane an exothermic process or an endothermic process?
c. Compare the energy change involved in the combustion of propane to the condensation of water. What is the factor difference between the energy involved in these processes?

Check your work with the answer in the Appendix.

How do you know if a chemical change has occurred? The key to identifying a chemical change is being able to detect the formation of a new substance. All chemical reactions involve the production of new substances. Several clues indicate a chemical change has occurred:

- colour change
- odour (smell) change
- state change—usually bubbles indicating a gas is formed or a solid precipitate is forming
- energy change—most commonly detected by a change in temperature

It is important to understand that these clues are a general guide and that identifying one of these changes doesn't necessarily indicate a chemical change. For example, if you heat water above 100°C, it will boil and produce bubbles. However, these bubbles are due to the state of water being changed. It is not a chemical change, since no new substance is formed. In cases where the evidence is unclear, you can often use simple diagnostic tests to determine whether a new product has been formed.

Self-Check

SC 2. Which of the following changes are physical, and which are chemical?

a. Copper wire is made from sheets of copper.

b. Fruit juices containing sugar ferment when yeast is added.

c. Oxygen is liquefied.

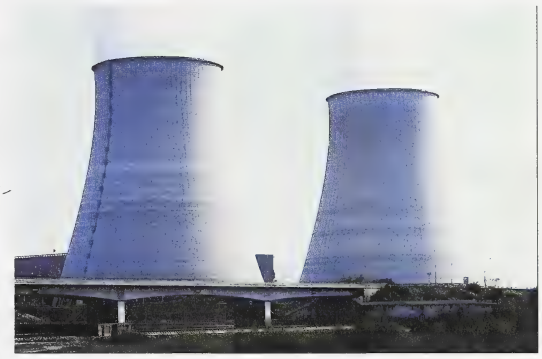
d. Sodium metal, Na(s), reacts violently with water to produce sodium hydroxide and hydrogen gas.

e. Naphthalene (mothballs) sublimes (changes directly from the solid state to the gas state).

f. Butane, a hydrocarbon, undergoes combustion.

Check your work with the answer in the Appendix.

Nuclear Change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The particle theory of matter applies to the subatomic particles that make up atoms. Subatomic particles are influenced by the nuclear force—the force of attraction between protons, between neutrons, and between protons and neutrons. Nuclear forces are much stronger than the forces between electrons and protons that result in chemical bonds. In fact, the nuclear force is the strongest force known. Since extremely large forces are needed to hold nuclear particles together, extremely large quantities of energy are required to break these intranuclear bonds and extremely large quantities of energy are released when subatomic particles reassemble. In a nuclear reaction, the rearrangement of protons and neutrons causes new products to be formed. In the case of a nuclear power plant, energy in the form of radiation is emitted.

Example

Uranium is a common nuclear fuel. The nuclear reaction involving uranium-235 is illustrated below.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}n \rightarrow 3\,{}^{1}_{0}n + {}^{35}_{92}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 1.85\times10^{10}\ \mathrm{kJ}$$

In this equation you will notice that *n* represents a neutron and that the process yields different kinds of atoms due to the rearrangement of protons and neutrons that occur.

Notice that the energy involved in the nuclear change is incredibly large (1.85×10^{10} kJ) compared to that of a chemical change (2220 kJ) or phase change (6.01 kJ and 40.65 kJ).

The following is a summary:

- Phase changes involve the rearrangement of particles that affect the bonds between particles (intermolecular bonds). These changes are characterized by having relatively small energy changes and no new substances formed.

- Chemical changes involve the rearrangement of particles that affect the bonds within a particle (intramolecular bonds). Chemical changes are characterized by having larger energy changes and the formation of new substances with new properties.

- Nuclear changes involve the rearrangement of sub-atomic particles within an atom (nuclear bonds). These changes are characterized by having massive energy changes, the formation of new elements, and the release of radiation.

Read

In the *Nelson Chemistry* textbook, read "The Kinetic Molecular Theory" on pages 47 to 49. Can you identify aspects of the particle theory that are consistent with the kinetic molecular theory? Prepare a list for your notes, and place a copy in your chemistry folder.

Self-Check

SC 3. Complete questions 10(a) and 10(b) on page 50 of the textbook.

Check your work with the answer in the Appendix.

Reflect and Connect

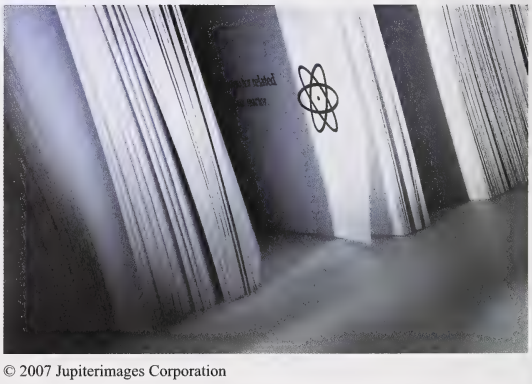
Draw cartoons representing physical, chemical, and nuclear changes. Ensure your artwork illustrates the similarities and differences between the three types of change. Incorporate an understanding of the particle model of matter and the kinetic molecular theory. Share your cartoons with your teacher. Place copies of your cartoons into your chemistry folder, along with any comments and revisions you make based on teacher feedback.

Discuss

Based on your research, post a message on the bulletin board that states your position for or against the use of nuclear technology. Give a brief explanation supporting your position. How have the lessons in Module 1 reshaped your views of nuclear technology? Feel free to comment on other opinions. Place a copy of your posting into your course folder.

Reflect on the Big Picture

In Module 1 you learned about the role of science and technology in society, elements and ions, ionic compounds, molecular compounds, chemical change, and the kinetic molecular theory. You explored the roles of modelling, evidence, and theories when explaining and understanding the structure, bonding, and properties of ionic and molecular compounds. Throughout the module you studied these concepts in the context of nuclear energy, shaping your perspectives and understandings of nuclear technology.



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Assessment

You should now have all the information you need to complete your final module project. Submit your projec

to your teacher when you are finished. Use the following guide to ensure your project covers all aspects of the project.

A mark out of 5 will be given for each project component according to the following guidelines.

Score	Criteria
5 **Excellent**	The student demonstrates an **excellent** understanding of the **component** of the project and fully and correctly supports opinions using relevant facts and details. Statements made in the response are organized, unambiguous, and are supported explicitly but may contain a minor error or have minor omissions.
4 **Good**	The student demonstrates a **good** understanding of the **component** of the project and fully and adequately supports opinions using facts and details. Statements made in the response are unambiguous, mostly complete, mostly correct, but may contain errors.
3 **Satisfactory**	The student demonstrates a **basic** understanding of the **component** of the project. Statements made in the response may be disorganized, ambiguous, incomplete, and may lack support.
2 **Limited**	The student demonstrates a **limited** understanding of the **component** of the project. Statements made in the response lack details, clarity, and support.
1 **Poor**	The student provides a solution that contains a relevant statement that begins to address the objective of the project component.
0 **Insufficient**	The response is incorrect and/or totally off topic.

Your project will be assessed based on the following criteria.

Project Components	Weighting
clearly states a position and supports it by evaluating risk-benefit of nuclear technology	5
communicates ideas using appropriate strategies	5
considers complex issues from multiple perspectives	5
Demonstration of Specific Knowledge	**Weighting**
Lesson 2 Research • What isotope of uranium exists? • What isotope of uranium is used in the CANDU process? • What is half-life? • What is the half-life of the isotope of uranium used in a CANDU reactor? • How does the uranium used in a CANDU reactor exist in nature? What processes are used to prepare the uranium for use in a reactor? • What isotopes are produced as waste from a CANDU nuclear reactor? • How is waste material from a CANDU reactor stored and disposed?	5
Lesson 3 Research • How does the uranium used in a CANDU reactor exist in nature? What processes are used to prepare the uranium to be used in a CANDU reactor? • What concerns exist about the mining and the processing of natural sources of uranium? • How have uranium mining and extraction facilities affected communities?	5
Lesson 4 Research • What kind of radiation is classified as ionizing radiation? • What effect does ionizing radiation have on water? • Why is there concern about changes to matter as a result of exposure to ionizing radiation?	5
Research Skills	**Weighting**
appropriate selection of resources representing a range of viewpoints	5
proper citation of sources at the conclusion of the project (e.g., a bibliography)	5
	Total of 40 marks

Complete the final module project, and submit it to your teacher.

Lesson Summary

Reflect on the critical questions asked at the beginning of this lesson:

- What is the particle model of matter?
- What is the kinetic molecular theory?
- What are the types of changes in matter, and what evidence is there that a chemical change has occurred?

In this lesson you compared and contrasted physical changes, chemical changes, and nuclear changes.

- Phase changes involve the rearrangement of particles that affect the bonds between particles (intermolecular bonds). These changes are characterized by having relatively small energy changes and no new substances formed.
- Chemical changes involve the rearrangement of particles that affect the bonds within a particle (intramolecular bonds). Chemical changes are characterized by having larger energy changes and the formation of new substances with new properties.
- Nuclear changes involve the rearrangement of sub-atomic particles within an atom (nuclear bonds). These changes are characterized by having massive energy changes, the formation of new elements, and the release of radiation.

You took a brief look at the kinetic molecular theory, which states that the tiny entities within any substance are constantly in random motion. This led you to the study of the collision-reaction theory in which the motion of entities results in collisions and the possibility of new substances forming in a chemical reaction. You reviewed the law of conservation of mass, which states that the total mass present before a chemical change is equal to the total mass present after a chemical change.

Lesson Glossary

endothermic process: a change in matter that requires an input of energy to occur

exothermic process: a change in matter that releases energy when it occurs

intermolecular: existing or acting between molecules

nuclear change: a process that causes an alteration to the composition of an atom's nucleus

physical change: a change in the form of a substance in which its chemical composition is unchanged

Module Summary

In this module you discovered that science is a complex mix of observation and theory.

A salt crystal can be easily observed: it is a hard, white, crystalline solid. However, if you want to know which elements make up that salt crystal or why it has the properties it does, an understanding of theoretical concepts is required.

A theoretical entity you studied extensively in this module is the electron. Electrons play a vital role in chemistry since all chemical bonding is the result of electron behaviour. A salt crystal is a hard, ionic solid because an electron is transferred from a sodium atom to a chlorine atom that results in a strong, ionic bond. Other compounds, however, do not form an ionic bond; they form a covalent bond.

A molecule of methane contains carbon and hydrogen atoms that share an electron. The nature of a chemical bond can be determined by looking at the electronegativity differences between atoms making up the compound. Depending on how large this difference is, a compound may be nonpolar covalent, covalent, or ionic.

Finally, you studied the kinetic molecular theory, which states that the tiny entities within any substance are continuously in random motion. This theory helps answer many questions, such as why chemical reactions occur, why ink spreads more slowly in cold water than in hot water, and why a balloon shrinks when put in a freezer. You will learn the answers to these questions as you proceed through this course.

Module Assessment

The assessment in this module consists of two assignments, as well as a final module project.

- Lesson 2 Assignment (in Module 1 Assignment Booklet)
- Lesson 3 Assignment (in Module 1 Assignment Booklet)
- Module Project on Nuclear Technology

In Module 1 you will be required to complete a module project. You will be required to prepare a speech, letter, report, or multimedia presentation that promotes nuclear technology or speaks against nuclear technology. For more information, you can read "Appendix D: STS Problem Solving" on page 806 of your textbook.

A mark out of 5 will be given for each project component according to the following guidelines.

Score	Criteria
5 **Excellent**	The student demonstrates an **excellent** understanding of the **component** of the project and fully and correctly supports opinions using relevant facts and details. Statements made in the response are organized, unambiguous, and are supported explicitly but may contain a minor error or have minor omissions.

4 **Good**	The student demonstrates a **good** understanding of the **component** of the project and fully and adequately supports opinions using facts and details. Statements made in the response are unambiguous, mostly complete, mostly correct, but may contain errors.
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1 **Poor**	The student provides one or more relevant but unconnected statements that address some aspects of the project.
0 **Insufficient**	The response is incorrect and/or totally off topic.

Your project will be assessed based on the following criteria.

Project Components	**Weighting**
clearly states a position and supports it by evaluating risk-benefit of nuclear technology	5
communicates ideas using appropriate strategies	5
considers complex issues from multiple perspectives	5
Demonstration of Specific Knowledge	**Weighting**
Lesson 2 Research • What isotope of uranium exists? • What isotope of uranium is used in the CANDU process? • What is half-life? • What is the half-life of the isotope of uranium used in a CANDU reactor? • How does the uranium used in a CANDU reactor exist in nature? What processes are used to prepare the uranium for use in a reactor? • What isotopes are produced as waste from a CANDU nuclear reactor? • How is waste material from a CANDU reactor stored and disposed?	5

Lesson 3 Research • How does the uranium used in a CANDU reactor exist in nature? What processes are used to prepare the uranium to be used in a CANDU reactor? • What concerns exist about the mining and the processing of natural sources of uranium? • How have uranium mining and extraction facilities affected communities?	5
Lesson 4 Research • What kind of radiation is classified as ionizing radiation? • What effect does ionizing radiation have on water? • Why is there concern about changes to matter as a result of exposure to ionizing radiation?	5
Research Skills	**Weighting**
appropriate selection of resources representing a range of viewpoints	5
proper citation of sources at the conclusion of the project (e.g., a bibliography)	5
	Total of 40 marks

Module Glossary

atom: the smallest entity of an element that is characteristic of that element

binary ionic compound: a compound that contains only two kinds of monatomic ions

CANDU: Canadian Deuterium-Uranium reactor; a type of nuclear reactor

chemical formula: a series of symbols representing the atoms/ions, and their proportions, present in a pure substance

coefficient: a number used to represent the quantity of molecules or the formula unit of a substance; a number that precedes a chemical formula

compound: a pure substance that can be separated into its elements by heat or electricity; a substance containing atoms/ions of more than one element in a definite fixed proportion

ecological perspective: a perspective, either pro or con, referring to the relationships among living organisms and the environment

economic perspective: a perspective, either pro or con, relating to the production, distribution, and consumption of wealth

electron: a small, negatively charged subatomic particle; has a specific energy within an atom

electronegativity: a value that describes the relative ability of an atom to attract a pair of electrons

element: a pure substance that cannot be broken down into simpler chemical substances by any physical or chemical means; consists of only one kind of atom

empirical knowledge: knowledge gained through observation

endothermic process: a change in matter that requires an input of energy to occur

energy level: a specific energy an electron can have in an atom or ion

ethical perspective: a perspective that bases decisions around accepted beliefs of a group

exothermic process: a change in matter that releases energy when it occurs

family: see *group*

group: a set of elements with similar chemical properties; the elements in a vertical column in the main part of the periodic table; also called a family

hydrate: a substance containing loosely bonded water molecules

intermolecular: existing or acting between molecules

intramolecular force: the relatively strong bonds or forces of attraction and repulsion within a molecule; typically covalent bonds

ion: an entity with a net positive or net negative electrical charge due to the loss or gain of one or more electrons

ionic bond: the simultaneous attraction among positive and negative ions

ionic compound: a pure substance formed from the bond between a metal and a non-metal

kinetic molecular theory: the idea that the smallest entities of a substance—atoms, ions, or molecules—are in continuous motion, colliding with each other and objects in their path

molecular compound: a pure substance formed by covalently bonded non-metal atoms

molecule: an entity consisting of a group of non-metal atoms held together by covalent bonds

monatomic ion: a positively or negatively charged particle formed from a single atom by the loss or gain of electrons; also known as a simple ion

multiperspective view: a view based upon many perspectives on an issue, including both pro and con statements from each perspective

multi-valent: the ability of an atom to exist as ions with different charges

neutral: having neither acidic nor basic properties; having a net charge of zero (electrically neutral)

neutron: an uncharged subatomic particle present in the nuclei of most atoms

noble gas: elements listed in column 18 of the periodic table that demonstrate limited chemical reactivity

nuclear change: a process that causes an alteration to the composition of an atom's nucleus

period: a horizontal row of elements in the periodic table whose properties gradually change from metallic to non-metallic from left to right along the row

physical change: any change in the form of a substance in which the chemical composition does not change

political perspective: a perspective, either pro or con, relating to vote-getting actions or campaigning

polyatomic ion: a combination of two or more non-metal atoms that have a net charge not equal to zero

protons: positively charged subatomic particles found in the nucleus

radiation: energy released or transmitted in the form of rays, waves, or particles

scientific perspective: a perspective, either pro or con, relating to researching (describing, explaining, and predicting) natural and technological phenomena

societal perspective: a perspective that focuses on ways in which society functions and the ways in which people interact

solubility: the concentration of a saturated solution at a specified temperature

technological perspective: a perspective, either pro or con, referring to the development and use of machines, instruments, and processes that have a social purpose

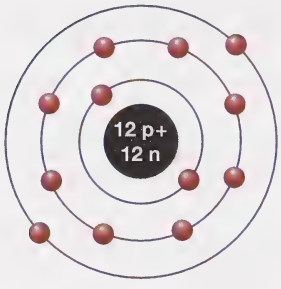
water of crystallization: water within a crystal, which is necessary for the maintenance of crystalline properties but capable of being removed by sufficient heat

Self-Check Answers

Lesson 2

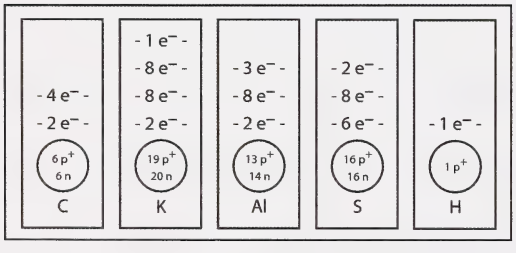
SC 2. Calcium has an atomic number of 20. This means there are 20 protons in the nucleus and 20 electrons orbiting around the nucleus. The atomic mass is 40.08. To determine the number of neutrons in the nucleus, simply subtract the atomic number from the atomic mass to get a value of 20 neutrons.

SC 3. With an atomic number of 12, there will be 12 protons in the nucleus and 12 electrons orbiting the nucleus. The atomic mass is 24.31, so there are 12 neutrons in the nucleus. Because magnesium has 12 electrons, 2 electrons appear in the first orbital, 8 electrons appear in the second orbital, and the remaining 2 electrons appear in the third orbital.

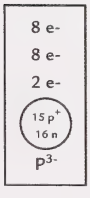


Mg

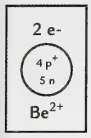
SC 4.



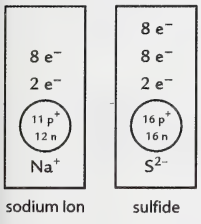
SC 5. Draw the phosphide ion. The phosphorus atom has 15 protons and 16 neutrons. In a phosphorus atom, the electrons are placed into three energy levels with 2, 8, and 8 electrons, respectively, from the innermost energy level to the outermost level. The phosphorus atom will gain 3 electrons to fill its valence orbital and become the phosphide ion. With this gain of electrons, the atom is no longer neutral; it now has 3 extra negative charges. This charge is included with the symbol as shown.



SC 6. The beryllium atom has 4 protons and 5 neutrons. It has 4 electrons placed in a 2-2 configuration. The beryllium atom will lose 2 valence electrons to become a beryllium ion. With this loss of electrons, the beryllium atom now has 2 extra protons compared to electrons. This shows up as a 2+ charge on the ion. Its electron configuration is now like helium, the nearest noble gas.



SC 7.



sodium Ion sulfide

Lesson 3

SC 1.

a. magnesium bromide
b. aluminium sulfide
c. Be_3N_2
d. K_3P
e. calcium oxide

SC 2.

a. CuO is named copper(II) oxide.
b. The formula for mercury(II) nitride is Hg_3N_2.
c. The formula for tin(IV) sulfide is SnS_2.
d. $FeCl_3$ is named iron(III) chloride.

SC 3.

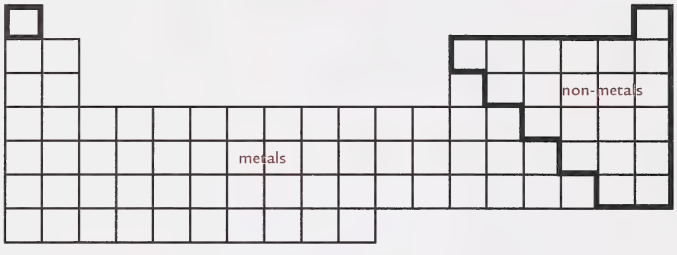
a. $BaCO_3$ is barium carbonate.
b. $Ni_2(SO_4)_3$ is nickel(III) sulfate.
c. The formula for potassium dichromate is $K_2Cr_2O_7$.
d. The formula for mercury(II) hydrogen carbonate is $Hg(HCO_3)_2$.
e. NH_4MnO_4 is ammonium permanganate.
f. The formula for ammonium oxide is $(NH_4)_2O$.

SC 4.

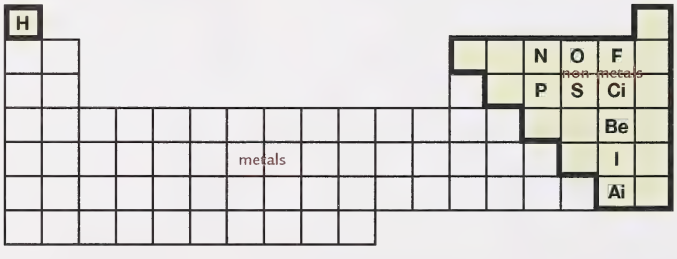
Chemical Name	Chemical Formula
sodium sulfate–water (1/10)	$Na_2SO_4 \cdot 10H_2O$
calcium hydrogen phosphate–water (1/2)	$CaHPO_4 \cdot 2H_2O$
barium chloride–water (1/2)	$BaCl_2 \cdot 2H_2O$
sodium carbonate–water (1/10)	$Na_2CO_3 \cdot 10H_2O$

Lesson 4

SC 1. Use the following chart to answer your question. The non-metals are placed on the right side of the table.



SC 2. The following chart shows the location of the molecular elements.



SC 3.

a. carbon monoxide
b. tetraphosphorus decaoxide
c. iodine

SC 4.

a. N_2O_4
b. CS_2
c. F_2

SC 5.

9.

a.

H	Cl	Difference in Electronegativity	Classification
2.2	3.2	1.0	polar covalent

b.

C	H	Difference in Electronegativity	Classification
2.6	2.2	0.4	polar covalent

c.

N	O	Difference in Electronegativity	Classification
3.0	3.4	0.4	polar covalent

d.

I	Br	Difference in Electronegativity	Classification
2.7	3.0	0.3	polar covalent

e.

Mg	S	Difference in Electronegativity	Classification
1.3	2.6	1.3	ionic bond (The bond is between a metal and a non-metal.)

f.

P	H	Difference in Electronegativity	Classification
2.2	2.2	0	nonpolar covalent

10.

a.

H	Br	Difference in Electronegativity	Classification
2.2	3.0	0.8	polar covalent

b.

Li	F	Difference in Electronegativity	Classification
1.0	4.0	3.0	ionic bond (The bond is between a metal and a non-metal.)

c.

C	C	Difference in Electronegativity	Classification
2.6	2.6	0	nonpolar covalent

SC 6.

Type of Covalent Bond	nonpolar covalent	polar covalent
Distinguishing Aspect	The electronegativities of atoms involved are identical.	The electronegativities of atoms are different.
Examples	O_2 , F_2	N-H, C-Cl

Lesson 5

SC 1.

a. The covalent bonds between C-C and C-H atoms in propane and the O-O bonds are broken and new bonds, between C-O and H-O atoms, are formed to make the products of the reaction.

b. The reaction shows that energy is a product of the reaction. Therefore, the reaction is exothermic.

c. $\frac{\text{Energy change of combustion of propane}}{\text{Energy change of condensation of water}} = \frac{2220\ \text{kJ}}{40.65\ \text{kJ}} = 54.61$

The energy change from the combustion of propane is 54.61 times greater than the energy change for the condensation of water.

SC 2.

a. physical
b. chemical
c. physical
d. chemical
e. physical
f. chemical

SC 3.

Textbook question 10(a)

Mixture 1	state change
Mixture 2	colour change
Mixture 3	state change
Mixture 4	odour change
Mixture 5	energy change
Mixture 6	state change
Mixture 7	colour change
Mixture 8	state change
Mixture 9	no change
Mixture 10	state change

Textbook question 10(b)

The mixture that did not appear to have a chemical reaction is Mixture 9.

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